GOVERNMENT BOTANICAL GARDENS
LIBRARY.
Section.....
No.....

FORTY-NINTH ANNUAL REPORT

OF THE

SECRETARY

OF THE

STATE BOARD OF AGRICULTURE,

OF THE

STATE OF MICHIGAN

AND

TWENTY-THIRD ANNUAL REPORT

OF THE

EXPERIMENT STATION

FROM

JULY 1, 1909, TO JUNE 30, 1910.

BY AUTHORITY

LANSING, MICHIGAN
WYNKOOP HALLENBECK CRAWFORD CO., STATE PRINTERS
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REPORT OF THE SECRETARY

OF THE

STATE BOARD OF AGRICULTURE

AGRICULTURAL COLLEGE, *July 1, 1910.*

TO HON. FRED M. WARNER,
Governor of the State of Michigan:

SIR—I have the honor to submit to you herewith, as required by law, the accompanying report for the fiscal year ending June 30, 1910, with supplementary papers.

Very respectfully,

ADDISON M. BROWN,
Secretary of the State Board of Agriculture.

GOVERNMENT BOTANICAL GARDENS
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STATE BOARD OF AGRICULTURE.

	Term expires.
ROBERT D. GRAHAM, Grand Rapids - - -	Dec. 31, 1913
Chairman of the Board.	
WILLIAM L. CARPENTER, Detroit, - - -	Dec. 31, 1911
WILLIAM J. OBERDORFFER, Stephenson, - -	Dec. 31, 1911
ALFRED J. DOHERTY, Clare, - - - - -	Dec. 31, 1913
WILLIAM H. WALLACE, Bay Port, - - - -	Dec. 31, 1915
I. ROY WATERBURY, Detroit, - - - -	Dec. 31, 1915
LUTHER L. WRIGHT, Supt. of Public Instruction, -	*Ex-Officio.*
JONATHAN L. SNYDER, President of the College, -	*Ex-Officio.*

ADDISON M. BROWN, East Lansing, Secretary.
BENJAMIN F. DAVIS, Lansing, Treasurer.

STANDING COMMITTEES.

Division of Agriculture, - -	I. R. Waterbury, R. D. Graham.
Division of Engineering, - -	A. J. Doherty, W. L. Carpenter.
Division of Home Economics, -	W. J. Oberdorffer, I. R. Waterbury.
Division of Science and Letters,	W. L. Carpenter, W. J. Oberdorffer.
Experiment Station, - - -	W. H. Wallace, A. J. Doherty.
Employees, - - - - -	R. D. Graham, W. L. Carpenter.
Finance, - - - - - -	R. D. Graham, W. H. Wallace.
Farmers' Institutes, - - -	A. J. Doherty, W. H. Wallace.
Buildings and College Property,	I. R. Waterbury, W. J. Oberdorffer.

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MICHIGAN AGRICULTURAL COLLEGE.

(Under control of the State Board of Agriculture.)

FACULTY AND OTHER OFFICERS.

JONATHAN L. SNYDER, A. M., Ph. D., LL. D., President; [a b c] Feb. 25, '96.

WM. J. BEAL, Ph. D., D. Sc., Professor of Botany; [a b] July 9, '70; [c] Sept. 1, '02.

FRANK S. KEDZIE, M. S., Professor of Chemistry; [a] Sept. 15, '80; [b c] Sept. 1, '02.

LEVI R. TAFT, M. S., Superintendent of Farmers' Institutes and State Inspector of Orchards and Nurseries; [a] Aug. 1, '88; [b c] July 1, '02.

HERMAN K. VEDDER, C. E., Professor of Civil Engineering; [a b] Sept. 15, '91; [c] July 7, '09.

WALTER B. BARROWS, B. S., Professor of Zoology and Physiology, and Curator of the General Museum; [a b c] Feb. 15, '94.

CHARLES E. MARSHALL, Ph. D., Professor of Bacteriology and Hygiene; [a] July 20, '96; [b c] Sept. 1, '02.

JOSEPH A. JEFFERY, B. S. A., Professor of Soils and Soil Physics; [a] Sept. 1, '99; [b c] Aug. 6, '08.

MAUDE GILCHRIST, B. S., A. M., Dean of Home Economics; [a b c] Sept. 1, '01.

ADDISON M. BROWN, A. B., Secretary of the College; [a b c] June 1, '02.

ROBERT S. SHAW, B. S. A., Dean of Agriculture; [a b] Sept. 1, '02; [c] Jan. 15, '08.

CHESTER L. BREWER, B. S., Professor of Physical Culture and Director of Athletics; [a b c] Sept. 1, '03.

ARTHUR R. SAWYER, B. S., E. E., Professor of Physics and Electrical Engineering [a b c] April 11, '04.

WARREN BABCOCK, B. S., Professor of Mathematics; [a b] June 30, '91; [c] July 7, '09.

RUFUS H. PETTIT, B. S. in Agr., Professor of Entomology; [a] Jan. 1, '97; [b c] Sept. 1, '06.

THOMAS C. BLAISDELL, Ph. D., Professor of English Literature and Modern Languages; [a b c] Sept. 1, '06.

WILBUR O. HEDRICK, M. S., Ph. D., Professor of History and Economics; [a b] Aug. 24, '91; [c] June 20, '06.

GEORGE W. BISSELL, M. E., Dean of Engineering and Professor of Mechanical Engineering; [a b c] June 18, '07.

*LESLIE M. HURT, D. V. M., Professor of Veterinary Science; [a b c] Sept. 4, '07.

J. Fred Baker, M. F., Professor of Forestry and Supervisor of Forest Reserve Lands; [a b c] Oct. 1, '07.

Harry J. Eustace, B. S., Professor of Horticulture; [a b c] Aug. 15, '08.

Victor T. Wilson, M. E., Professor of Drawing & Design; [a b c] Sept. 1, '08.

Walter H. French, Professor of Agricultual Education; [a b c] Sept. 1, '08.

Lieut. George M. Holley, M. S., Professor of Military Science and Tactics; [a b c] Sept. 1, '09.

Vernon M. Shoesmith, B. S., Professor of Farm Crops; [a b c] Feb. 14, '09.

Chace Newman, Assistant Professor of Drawing; [a] Sept. 1, '97; [b c] Sept. 1, '07.

Jesse J. Myers, B. S., Assistant Professor of Zoology; [a b] Sept. 1, '01; [c] June 26, '07.

E. Sylvester King, Assistant Professor of English; [a] Jan. 1, '00; [b c] Sept. 1, '02.

James B. Dandeno, A. M., Ph. D., Assistant Professor of Botany; [a b c] Sept. 1, '02.

Harry S. Reed, B. S., Assistant Professor of Chemistry; [a b] May 2, '05; [c] Sept. 1, '07.

Edward H. Ryder, M. A., Assistant Professor of History and Economics; [a b] Sept. 1, '05; [c] May 2, '07.

A. Crosby Anderson, B. S., Associate Professor of Dairy Husbandry; [a] Sept. 1, '05; [b c] June 10, '09.

Joseph A. Polson, B. S., Assistant Professor of Mechanical Engineering; [a b] Sept. 1, '06; [c] May 7, '08.

F. Hobart Sanford, B. S., Assistant Professor of Forestry; [a b] Dec. 1, '06; [c] May 1, '09.

Charles P. Halligan, B. S., Assistant Professor of Horticulture ; [a b] April 8, '07; [c] May 7, '08.

Otto Rahn, Ph. D., Assistant Professor of Bacteriology; [a] Sept. 1, '07; [b c] Sept. 1, '08.

Louis L. Appleyard, B. S., Assistant Professor of Mechanical Engineering; [a] May 2, '07; [b c] Sept. 1, '08.

Anton S. Rosing, B. S., in C. E., Assistant Professor of Civil Engineering; [a b c] Sept. 1, '09.

W. Lloyd Lodge, B. S., M. A., Assistant Professor of Physics; [a b] Oct. 1, '06; [c] Apr. 28, '09.

Arthur J. Clark, A. B., Assistant Professor of Chemistry; [a b] Sept. 1, '06; [c] June 10, '09.

Thomas Gunson, Instructor in Horticulture and Superintendent of the Grounds; [a b] April 1, '91; [c] Sept. 1, '05.

Caroline L. Holt, Instructor in Drawing; [a b c] Sept. 1, '98.

Louise Freyhofer, B. S., Instructor in Music; [a b c] Sept. 1, '02.

*Albert E. Jones, A. B., Instructor in Mathematics; [a b c] Sept. 15, '03.

Norma L. Gilchrist, A. B., Instructor in English and German; [a b c] Sept. 1, '05.

Wylie B. Wendt, B. C. E., Instructor in Civil Engineering; [a b] Sept. 1, '06; [c] June 10, '09.

L. Zae Northrup, B. S., Instructor in Bacteriology, [a b c] Sept. 1, '07.

A. Watt, Instructor in Blacksmithing; [a b c] April 1, '09.

PEARL MAC DONALD, A. B., B. S., Instructor in Domestic Science; [a b c] Sept. 1, '07.

ORESTES I. GREGG, B. S., Instructor in Horticulture; [a b c] Sept. 1, '07.

MRS. MINNIE HENDRICK, A. B., Instructor in History and Economics; [a] Sept. 1, '07; [b c] Sept. 1, '08.

WALLACE B. LIVERANCE, B. S., Instructor in Dairying; [a b c] Sept. 1, '07.

WILLIAM A. ROBINSON, A. B., S. T. B., Instructor in English; [a b c] Sept. 1, '07.

ROSE M. TAYLOR, A. B., Instructor in Botany; [a b c] Feb. 8, '08.

ARTHUR E. FISH, A. B., Instructor in English; [a b c] Sept. 1, '08.

HERMAN HENSEL, A. B., Instructor in German and English; [a b c] Sept. 1, '08.

HELEN I. MICHAELIDES, Instructor in French and English; [a b c] Sept. 1, '08.

LEWIS S. FULLER, B. S., Instructor in Civil Engineering; [a b] Sept. 1, '08; [c] April 28, '09.

ISABEL PEARL SNELGROVE, Instructor in Drawing; [a b c] Sept. 1, '08.

GEO. A. BROWN, B. S., Instructor in Animal Husbandry; [a b c] Sept. 1, '08.

SHEPHERD LEFFLER, A. B., Instructor in History; [a b c] Sept. 1, '08.

KATE COAD, B. S., Instructor in Domestic Art; [a b c] Sept. 1, '08.

ROSEMUND H. KEDZIE, B. S., Instructor in Domestic Art; [a b c] Sept. 1, '08.

MABEL LONG, Instructor in Physical Culture; [a b c] Sept. 1, '08.

MRS. LILLIAN L. PEPPARD, Instructor in Domestic Art and Domestic Science; [a b c] Sept. 1, '08.

WILLIAM E. LAYCOCK, Instructor in Physics; [a b c] Sept. 1, '08.

WARD H. PARKER, B. S., Instructor in Chemistry; [a b c] Sept. 1, '08.

*MERRILL A. YOTHERS, B. S., Instructor in Entomology; [a b c] July 1, '08.

MARGARET B. DUPEE, S. B., Instructor in Botany; [a b c] Jan. 1, '09.

ANTIONETTE A. ROBSON, Instructor in German and English; [a b c] Jan. 1, '09.

ROSCOE GILMORE STOTT, A. B., Instructor in English; [a b c] April 1, '09.

MAURICE F. JOHNSON, B. S., Instructor in Mathematics; [a b c] April 1, '09.

HECTOR MAC PHERSON, M. S., Instructor in Economics and Sociology; [a b c] Jan. 1, '09.

HERBERT E. MARSH, B. S., Instructor in Physics; [a b c] Jan. 1, '09.

BENJAMIN B. ROSEBOOM, Jr., Instructor in Zoology; [a b c] Jan. 15, '09.

CHAS. H. SPURWAY, B. S., Instructor in Soil Physics; [a b c] Sept. 1, '09.

HARRY L. KEMPSTER, B. S., Instructor in Poultry Husbandry; [a b c] Sept. 1, '09.

HARRY H. MUSSELMAN, Instructor in Farm Mechanics; [a b c] Sept. 1, '09.

JOHN BOWDITCH, Instructor in Animal Husbandry; [a b c] Sept. 1, '09.

GEORGE A. KELSALL, B. S., Instructor in Electrical Engineering; [a b c] Sept. 1, '09.

BELLE FARRAND, B. S., Instructor in Bacteriology; [a] July 1, '06; [b c] July 1, '09.

ANNA BELL LEE, A. B., Instructor in Botany; [a b c] Jan. 1, '10.

R. DE ZEEUW, Ph. D., Instructor in Botany; [a b c] Sept. 1, '09.

MAX L. TOWAR, B. S., Instructor in Chemistry; [a b c] Sept. 1, '09.

CLARENCE M. HARGRAVE, A. B., Instructor in Chemistry; [a b c] Sept. 1, '09.

HERMAN M. POTTER, A. B., Instructor in Chemistry; [a b c] Jan. 1, '10.

*Chas. N. Wilson, B. C. E., Instructor in Civil Engineering; [a b c] Sept. 1, '09.
J. T. Buser, B. S., Instructor in Civil Engineering; [a b c] Sept. 1, '09.
Chas. C. Cobb, B. S., Instructor in Drawing; [a b c] Sept. 1, '09.
Paul N. Ford, B. S., C. E., Instructor in Drawing; [a b c] Sept. 1, '09.
George F. Williamson, A. B., Instructor in English; [a b c] Sept. 1, '09.
William E. Sloat, A. B., Instructor in English; [a b c] Sept. 1, '09.
Chas. L. Wuebker, Sc. B., Instructor in English and German; [a b c] Sept. 1, '09.
Eugenia Mc Daniel, A. B., Instructor in Entomology; [a b c] April 1, '10.
Richard H. Reece, B. S., Instructor in Mathematics; [a b c] Jan. 1, '10.
Stanley E. Crowe, B. A., Instructor in Mathematics; [a b c] Sept. 1, '09.
James E. Robertson, B. S., Instructor in Mathematics, Sept. 1, '09.
Ernest E. Beighle, B. S., Instructor in Mathematics; [a b c] Sept. 1, '09.
Lloyd C. Emmons, B. S., A. B., Instructor in Mathematics; [a b c] Sept. 1, '09.
Karl E. Hopphan, B. S., Instructor in Mathematics; [a b c] Sept. 1, '09.
Hugh A. Snepp, B. S., Instructor in Mathematics; [a b c] Sept. 1, '09.
William H. Hartman, B. S., Instructor in Mechanical Engineering; [a b c] Sept. 1, '09.
Ernest Roller, B. S., A. M., Instructor in Physics; [a b c] Sept. 1, '09.
Edna Hopson, Assistant Instructor in Music; [a b c] Sept. 1, '09.
Frederick A. Burt, B. S., Instructor in Zoology; [a b c] Sept. 1, '09.
Harold S. Osler, B. S., Instructor in Zoology; [a b c] Sept. 1, '09.
Serg. P. J. Cross, Instructor in Military Science & Tactics; [a b c] May 1, '10.
E. C. Baker, Foreman of the Foundry; [a b c] Nov. 1, '97.
Andrew P. Krentel, Foreman of the Wood Shop; [a b c] Sept. 1, '02.
William R. Holmes, Foreman of the Forge Shop; [a b c] Sept. 1, '06.
Ralph S. Hudson, B. S., Farm Foreman; [a b c] Dec. 1, '07.
Carl C. Wilcox, M. E., E. E., Foreman of the Machine Shop; [a] Oct. 1, '07; [b c] Sept. 1, '08.
Albert H. Davis, Foreman of the Horticultural Department; [a b c] Sept. 1, '08.
W. F. Raven, Live Stock Field Agent; [a b c] April 1, '09.
A. R. Potts, Field Agent Soils and Crops; [a b c] Sept. 9, '09.
O. K. White, B. S., Horticultural Field Agent; [a b c] April 1, '09.
Linda E. Landon, Librarian; [a b c] Aug. 24, '91.
Agnes E. Crumb, Assistant Librarian; [a] Aug. 12, '07; [b c] March 1, '08.
Elida Yakeley, Registrar; [a] July 15, '03; [b c] June 1, '08.
E. C. Crawford, Shop Engineer; [a b c] July 1, '09.
Catherine M. Cameron, House Director; [a b c] Sept. 1, '09.
Chas. W. Brown, B. S., Assistant in Bacteriology; [a b c] Aug. 1, '06.
*Chas. A. Henley, Clerk to the President and Editor M. A. C. Record; [a b c] Sept. 1, '09.
Benjamin A. Faunce, Clerk to President and Editor M. A. C. Record; [a] Sept. 1, '99; [b c] Apr. 1, '10.
Jacob Schepers, Cashier; [a b] May 1, '07; [c] July 1, '07.
Luther F. Jenison, Bookkeeper; [a b c] May 1, '07.
John H. Rand, Purchasing Agent; [a b c] Aug. 1, '08.

MAUD A. MEECH, Clerk to Secretary; [a b c] April 1, '08.
*LILLIAN R. SHAFER, Clerk to Secretary; [a b c] March 15, '09.
LOUISE E. WALSWORTH, Clerk to Secretary; [a b c] Jan. 17, '10.
MRS. C. M. DUDD, Clerk to President; [a b c] Jan. 1, '10.
LORY F. NEWELL, Engineer; [a b c] Jan. 1, '98.
EDWYN A. BOWD, College Architect; [a b c] Jan. 1, '02.
ROWENA KETCHUM, Nurse in charge of College Hospital; [a b c] Sept. 1, '00.

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*Resigned.
a First appointment.
b Present appointment
c Present title.

AGRICULTURAL EXPERIMENT STATION

OF THE

MICHIGAN AGRICULTURAL COLLEGE

(Under the control of the State Board of Agriculture.)

STATION COUNCIL.

JONATHAN L. SNYDER, A. M., Ph. D., L. L. D., President, *Ex-officio.*
ROBERT S. SHAW, B. S. A., Director.
CHARLES E. MARSHALL, Ph. D., Scientific and Vice-Director and Bacteriologist.
HARRY J. EUSTACE, B. S., Horticulturist.
RUFUS H. PETTIT, B. S. A., Entomologist.
ANDREW J. PATTEN, B. S., Chemist.
JOSEPH A. JEFFERY, B. S. A., Soil Physicist.
WILLIAM J. BEAL, Ph. D., Sc., Botanist.
VERNON M. SHOESMITH, B. S., Farm Crops Experimenter.
ADDISON M. BROWN - - Secretary.

ADVISORY AND ASSISTANT STAFF.

CHARLES P. HALLIGAN, B. S., Asst. Horticulturist.
OTTO RAHN, Ph. D., Asst. Bacteriologist.
A. CROSBY ANDERSON, B. S., Asst. Dairy Husbandman
JAMES B. DANDENO, Ph. D., Asst. Botanist.
GEORGE A. BROWN, B. S., Asst. Animal Husbandman.
GEORGE D. SHAFER, Ph. D., Research Asst. in Entomology.
WARD GILTNER, D. V. M. M. S., Research Asst. in Bacteriology.
CHARLES W. BROWN, B. S., Research Asst. in Bacteriology.
FRANK A. SPRAGG, M. S., Asst. in Crops (Plant Breeding.)
MISS ZAE NORTHRUP, B. S., Asst. in Bacteriology.
MISS LULU M. SMITH, B. S., Asst. in Bacteriology.
MERRILL A. YOTHERS, B. S., Asst. in Entomology.
MRS. LINDA E. LANDON - Librarian.
CHARLES S. ROBINSON, M. S., Research Asst. in Chemistry.
W. ALLERTON WENTWORTH, B. S., Research Asst. in Bacteriology.
ORRIN B. WINTER, B. S., Asst. in Chemistry.
EUGENIA MCDANIEL, Asst. in Entomology.
MYRA V. BOGUE - Bulletin Clerk.

STANDING COMMITTEE IN CHARGE.

HON. WILLIAM H. WALLACE - - - - - - - - - Saginaw.
HON. ALFRED J. DOHERTY - - - - - - - - - - Clare.

ACCOUNTS

OF THE MICHIGAN AGRICULTURAL COLLEGE

FOR THE YEAR ENDING JUNE 30, 1910.

SECRETARY'S FINANCIAL REPORT.

			Dr.	Cr.
July 1, 1909.	To cash on deposit, college treasurer		$35,288 69	
July 1, 1909.	To cash on hand		1,398 16	
June 30, 1910.	To special appropriation receipts		76,616 43	
	From State Treasurer	$42,410 00		
	From United States Treasurer	28,000 00		
	From institution and other sources	6,206 43		
June 30, 1910.	By special appropriation disbursements			$91,433 25
June 30, 1910	To current account receipts		339,204 77	
	From State Treasurer, land grant interest	$71,109 49		
	From State Treasurer, one tenth mill tax	145,000 00		
	From U. S. Treasurer, Morrill fund	40,000 00		
	From institution and other sources	82,073 21		
	From South Haven Experiment Station	440 67		
	From U. P. Experiment Station	581 40		
	By general account disbursements			343,660 78
	From current account	$321,910 90		
	From supplementary accounts	21,749 88		
June 30, 1910.	By cash on hand			2,748 87
June 30, 1910.	By cash on deposit			14,665 15
			$452,508 05	$452,508 05

TABLE NO. 1.—*Tabular exhibit of Secretary's report.*

	Balance sheet July 1, 1909.		Transactions, July 1, 1909, to June 30, 1910.		Balance sheet June 30, 1910.	
	Dr.	Cr.	Dr.	Cr.	Dr.	Cr.
Cash	$1,398 16	.....	.....	$1,350 71	$2,748 87	.....
College treasurer*	35,288 69	.....	$20,623 54	.....	14,665 15	.....
Special appropriations	.....	$26,889 67	76,616 43	91,433 25	.....	$12,072 85
Current accounts	.....	9,797 18	338,183 81	321,910 90	.....	5,341 17
Supplementary accounts	.....	.....	1,020 96	21,749 88	.....	.....
Totals	$36,686 85	$36,686 85	$436,444 74	$436,444 74	$17,414 02	$17,414 02

*Treasurer's statement is greater July 1, 1909, by $8,295.33 and June 30, 1910, by $5,951.23; warrants outstanding.

TREASURER'S ACCOUNT.

	Dr.	Cr.
Balance on hand July 1, 1909	$43,584 02	
Receipts from State Treasurer and secretary of college	414,015 11	
Interest on deposits during year	455 38	
Warrants paid July 1, 1909 to June 30, 1910		$437,438 13
Balance on hand June 30, 1910		20,616 38
Total	$458,054 51	$458,054 51

TABLE NO. 2.—*Statement of special appropriation account for fiscal year ending June 30, 1910.*

Name of appropriation.	Balance of accounts, July 1, 1909.		Receipts during fiscal year.		Total available.	Total expended.	Balance of account, June 30, 1910.	
	Dr.	Cr.	From State Treasurer.	From institution and other sources.			Dr.	Cr.
Experiment Station		$1,851 54	*$28,000 00	$4,425 22	$34,276 76	$31,724 64		$2,552 12
Nursery License and Inspection				1,133 00	1,133 00	1,133 00		
Sundry Improvements		1,877 27			1,877 27			1,877 27
Agricultural Building		22,846 96	28,000 00	140 69	50,987 65	49,882 20		1,105 45
Semi-Centennial		262 74		27	263 01	115 46		147 55
Addition to Botanical Building			13,410 00		13,410 00	7,033 55		6,376 45
Sayer Fund				507 25	507 25	494 75		12 50
Weather Bureau		51 16	1,000 00		1,051 16	1,049 65		1 51
Balance	$26,889 67							
Total	$26,889 67	$26,889 67	$70,410 00	$6,206 43	$103,506 10	$91,433 25		$12,072 85

*United States Treasurer.

TABLE NO. 3.—*Current account, June 1, 1909, to June 30, 1910.*

On account of—	Dr. To disbursements.	Cr. By Receipts.
U. S. Treasurer, 20th annual payment under act of Congress of August, 1890	.....	$40,000 00
State Treasurer, one tenth mill tax	.....	145,000 00
State Treasurer, interest on proceeds of sales of U. S. land grant	.....	71,109 49
Advertising	$2,648 10	136 67
Agricultural education	825 03	2 00
Animal husbandry	10,099 25	6,283 89
Athletics	1,319 74	1,494 23
Bacteriological	4,463 79	4,297 75
Botanical	2,162 02	76 12
Chemical	7,001 86	3,884 52
Cleaning	3,052 63	532 99
Civil engineering	3,952 45	506 40
College extension	1,843 02	.....
Contingent building	38,745 64	29,242 10
Receipts itemized: Diploma fees, $505.00; matriculation, $2,595.00; tuition, $1,680.00; incidental, $8,382.50; room rent, $10,646.98; sundry, $5,432.62.		
Dean's office	550 57	80 94
Drawing	1,055 70	37 71
Dairy husbandry	12,072 37	10,572 16
Electric lighting	5,494 10	2,176 39
English	383 53	96 00
Entomology	1,045 96	91 55
Farm horses	6,905 03	4,285 26
Forestry	4,642 60	676 68
Farm mechanics	1,284 88	826 27
Heating	27,492 13	1,316 79
History	132 50	39 00
Horticulture	6,868 12	1,320 34
Library	2,387 13	36 86
Mathematical	145 71	98 00
Mechanical	10,652 48	1,844 61
M. A. C. Record	1,358 92	643 35
Military	867 72	.....
Miscellaneous	4,509 72	2,559 51
Office, president's	1,017 86	9 20
Office, secretary's	1,557 62	475 74
Physical	1,786 04	751 10
Poultry	2,752 35	1,806 46
Registrar	581 04	.....
Salaries	138,747 14	1,696 25
Special courses	4,516 49	1,884 81
Soils	1,193 55	38 80
Telephones	1,147 48	381 53
Veterinary	161 24	3 00
Women's	2,745 48	1,506 04
Zoological	1,741 91	353 30
Total	$321,910 90	$338,173 81
Supplementary accounts:		
Bulletins	6,773 23	.....
Farmers' institutes	8,844 20	8 89
South Haven experiment station	2,112 14	440 67
Upper Peninsula experiment station	4,020 31	581 40
Balance beginning of period July 1, 1909	.....	9,797 18
Balance at close of period July 1, 1910	5,341 17	.....
Total	$349,001 95	$349,001 95

TABLE NO. 4.—*Experiment Station account for fiscal year ending June 30, 1910.*

On account of—	Disbursements.			Dr. To disbursements.	Cr. by Receipts.
	Adams.	Hatch.	State.		
Balance from fiscal year, July 1, 1909					$1,851 54
Bacteriological department	$5,063 73	$669 80	$179 39	$5,912 92	37 40
Botanical department	220 93	211 91	3 19	436 03	
Chemical department	697 63	1,452 86	1,020 28	3,170 77	3 35
Director's office		564 84	242 23	828 31	3 40
Entomological department	459 04	381 10	7 88	826 78	
Farm department		2,152 06	99 01	2,251 07	187 71
Horticultural department		1,629 62		1,629 62	1 74
Library		464 64		464 64	
Live stock					
Salaries	6,508 25	7,473 17	1,252 70	15,234 12	85 00
Secretary's office			914 51	914 51	60
Sundry			5 45	5 45	26 02
Soil Physicist	50 42			50 42	
Veterinary					
U. S. Treasurer for fiscal year					28,000 00
Fertilizer fees					4,080 00
Balance on hand June 30, 1910				2,552 12	
Total	$13,000 00	$15,000 00	$3,724 64	$34,276 76	$34,276 76

TABLE NO. 5.—*Positions and salaries as shown by pay roll dated June 30, 1910.*

Grade.	Rate per year.	Classification.		Other sources.	
		Current.	Experiment station.		
President's office:					
President	$5,000 00	$5,000 00	.....	.....	House.
Clerk	1,000 00	1,000 00	.....	.....	.....
Clerk	600 00	600 00	.....	.....	.....
Agricultural Department:					
Dean	3,000 00	2,000 00	$1,000 00	.....	House.
Professor of Agronomy	2,100 00	2,000 00	100 00	.....	.....
Professor Dairy Husbandry	1,700 00	1,500 00	200 00	.....	.....
Professor Animal Husbandry	1,000 00	800 00	200 00	.....	.....
Instructor Dairying	1,100 00	1,100 00	.....	.....	.....
Instructor Poultry Husbandry	1,000 00	1,000 00	.....	.....	.....
Instructor Farm Mechanics	1,000 00	1,000 00	.....	.....	.....
Instructor Soil Physics	800 00	800 00	.....	.....	.....
Professor Farm Crops	2,200 00	2,200 00	.....	.....	.....
Instructor Blacksmithing	660 00	660 00	.....	.....	.....
Foreman College Farm	750 00	750 00	.....	.....	.....
Field Agent, Live Stock	1,500 00	1,500 00	.....	.....	.....
Field Agent, Farm Crops	780 00	780 00	.....	.....	.....
Instructor Animal Husbandry	600 00	600 00	.....	.....	.....
Clerk	450 00	450 00	.....	.....	.....
Asst. to Farm Crops Experimenter	1,100 00	.....	1,100 00	.....	.....
Agricultural Education:					
Professor	2,200 00	2,200 00	.....	.....	.....
Bacteriological Department:					
Professor	3,000 00	2,000 00	1,000 00	.....	.....
Assistant Professor	1,400 00	1,250 00	150 00	.....	.....
Research Asst. in Bacteriology	1,350 00	.....	1,350 00	.....	.....
Research Asst. in Bacteriology	1,000 00	.....	1,000 00	.....	.....
Research Asst. in Bacteriology	1,000 00	250 00	750 00	.....	.....
Assistant in Bacteriology	600 00	250 00	350 00	.....	.....
Assistant in Bacteriology	500 00	.....	500 00	.....	.....
Assistant in Bacteriology	500 00	500 00	.....	.....	.....
Botanical Department:					
Professor	2,000 00	2,000 00	.....	.....	House.
Assistant Professor	1,400 00	1,300 00	100 00	.....	.....
Instructor	900 00	900 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Instructor	700 00	700 00	.....	.....	.....
Chemical Department:					
Professor	2,300 00	2,300 00	.....	.....	.....
Assistant Professor	1,400 00	1,400 00	.....	.....	.....
Instructor	1,250 00	1,250 00	.....	.....	.....
Instructor	900 00	900 00	.....	.....	.....
Instructor	900 00	900 00	.....	.....	.....
Instructor	765 00	765 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Chemist Experiment Station	2,000 00	.....	2,000 00	.....	.....
Research Asst. Chemistry Ex.Sta.	1,000 00	.....	1,000 00	.....	.....
Asst. in Chemistry, Exp. Sta.	900 00	.....	900 00	.....	.....
Civil Engineering Department:					
Professor	2,000 00	2,000 00	.....	.....	House.
Asst. Professor	1,400 00	1,400 00	.....	.....	.....
Instructor	1,200 00	1,200 00	.....	.....	.....
Instructor	1,200 00	1,200 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Instructor	720 00	720 00	.....	.....	.....
Drawing Department:					
Professor	2,300 00	2,300 00	.....	.....	.....
Asst. Professor	1,300 00	1,300 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	650 00	650 00	.....	.....	.....

TABLE NO. 5.—*Continued.*

Grade.	Rate per year.	Classification.		Other sources.	
		Current.	Experiment station.		
English Department:					
Professor	$2,000 00	$2,000 00	.....	.....	House.
Asst. Professor	1,300 00	1,300 00	.....	.....	.....
Instructor	1,000 00	1,000 00	.....	.....	.....
Instructor	850 00	850 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Instructor	700 00	700 00	.....	.....	.....
Instructor	650 00	650 00	.....	.....	.....
Entomological Department:					
Professor	1,900 00	1,100 00	$800 00	.....	House.
Instructor	800 00	450 00	350 00	.....	.....
Research Asst. in Entomology	1,350 00	.....	1,350 00	.....	.....
Forestry Department:					
Professor	2,000 00	2,000 00	.....	.....	.....
Asst. Professor	1,400 00	1,400 00	.....	.....	.....
History and Pol. Economy:					
Professor	2,000 00	2,000 00	.....	.....	.....
Asst. Professor	1,600 00	1,600 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	750 00	750 00	.....	.....	.....
Horticultural Department:					
Professor	2,000 00	1,400 00	600 00	.....	House.
Asst. Professor	1,500 00	1,000 00	500 00	.....	.....
Instructor	1,200 00	1,200 00	.....	.....	House.
Instructor	900 00	900 00	.....	.....	.....
Field Agent	1,200 00	1,200 00	.....	.....	.....
Foreman of Grounds	600 00	600 00	.....	.....	House.
Institute and Nursery Inspector:					
Superintendent	2,000 00	2,000 00	.....	.....	House.
Library:					
Librarian	1,000 00	880 00	220 00	.....	Rooms.
Asst. Librarian	550 00	550 00	.....	.....	.....
Mathematical Department:					
Professor	2,300 00	2,300 00	.....	.....	.....
Instructor	900 00	900 00	.....	.....	.....
Instructor	900 00	900 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	765 00	765 00	.....	.....	.....
Instructor	700 00	700 00	.....	.....	.....
Instructor	700 00	700 00	.....	.....	.....
Mechanical Department:					
Dean	3,000 00	3,000 00	.....	.....	House.
Asst. Professor	1,500 00	1,500 00	.....	.....	.....
Asst. Professor	1,400 00	1,400 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	720 00	720 00	.....	.....	.....
Instructor	660 00	660 00	.....	.....	.....
Foreman Machine Shop	1,300 00	1,300 00	.....	.....	.....
Foreman Wood Shop	800 00	800 00	.....	.....	.....
Foreman Foundry	800 00	800 00	.....	.....	.....
Foreman Forge Shop	800 00	800 00	.....	.....	.....
Shop Engineer	780 00	780 00	.....	.....	.....
Clerk	540 00	540 00	.....	.....	.....

TABLE NO. 5.—*Concluded.*

Grade.	Rate per year.	Classification.		Other sources.	
		Current.	Experiment station.		
Miscellaneous:					
Architect	$1,500 00	$1,500 00	.....	.....	.....
Engineer	1,200 00	1,200 00	.....	.....	.....
Plumber	900 00	900 00	.....	.....	.....
Night Watchman	600 00	600 00	.....	.....	.....
Nurse	450 00	450 00	.....	.....	.....
Registrar	900 00	900 00	.....	.....	.....
Sergeant	600 00	600 00	.....	.....	.....
Stenographer	480 00	480 00	.....	.....	.....
Stenographer	480 00	480 00	.....	.....	.....
Stenographer	480 00	480 00	.....	.....	.....
Stenographer	540 00	540 00	.....	.....	.....
Bulletin Clerk	480 00	.....	$480 00	.....	.....
Physics Department:					
Professor	2,300 00	2,300 00	.....	.....	.....
Asst. Professor	1,300 00	1,300 00	.....	.....	.....
Instructor	1,100 00	1,100 00	.....	.....	.....
Instructor	900 00	900 00	.....	.....	.....
Instructor	900 00	900 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Physical Culture Department:					
Director	2,000 00	2,000 00	.....	.....	.....
Secretary's Office:					
Secretary	2,250 00	550 00	700 00	$1,000 00	House.
Cashier	1,300 00	1,100 00	200 00	.....	.....
Bookkeeper	700 00	500 00	200 00	.....	.....
Clerk	850 00	725 00	125 00	.....	.....
Clerk	450 00	450 00	.....	.....	.....
Purchasing Agent	1,000 00	1,000 00	.....	.....	.....
Women's Department:					
Dean	1,600 00	1,600 00	.....	.....	Rooms.
Instructor Domestic Science	1,000 00	1,000 00	.....	.....	Rooms.
Instructor Music	1,000 00	1,000 00	.....	.....	.....
Instructor Domestic Art	700 00	700 00	.....	.....	Rooms.
Instructor Physical Culture	600 00	600 00	.....	.....	Rooms.
House Director	550 00	550 00	.....	.....	Rooms.
Asst. Domestic Art	500 00	500 00	.....	.....	Rooms.
Asst. Instructor in Music	500 00	500 00	.....	.....	Rooms.
Instructor Domestic Art	450 00	450 00	.....	.....	Rooms.
Zoological Department:					
Professor	2,000 00	2,000 00	.....	.....	House.
Asst. Professor	1,300 00	1,300 00	.....	.....	.....
Instructor	800 00	800 00	.....	.....	.....
Instructor	700 00	700 00	.....	.....	.....
Instructor	700 00	700 00	.....	.....	.....
Total	$165,350 00	$145,125 00	$17,225 00	$1,000 00	.....

TABLE NO. 6.—*Income of the Michigan Agricultural College from all outside sources from the date of its foundation to the present time.*

Year.	From State Legislature.			From U. S. Congress.			Total.
	For current expenses.	For special purposes.	Land sales, salt spring and swamp land grants.	Morrill act of 1862, interest from land grant and trespass.	Hatch act of 1887, and Adams act of 1906, experiment station.	Morrill act of 1890, supplementary endowment.	
1855..	.....	.....	$56,320 00	.....	.....	.....	$56,320 00
1856..	.....	.....	.....	.....	.....	.....	.....
1857..	$40,000 00	.....	.....	.....	.....	.....	40,000 00
1858..	.....	.....	.....	.....	.....	.....	.....
1859..	37,500 00	.....	.....	.....	.....	.....	37,500 00
1860..	.....	.....	.....	.....	.....	.....	.....
1861..	6,500 00	.....	152 25	.....	.....	.....	6,652 25
1862..	10,000 00	.....	218 97	.....	.....	.....	10,218 97
1863..	9,000 00	.....	407 80	.....	.....	.....	9,407 80
1864..	9,000 00	.....	726 09	.....	.....	.....	9,726 09
1865..	15,000 00	.....	1,156 61	.....	.....	.....	16,156 61
1866..	15,000 00	.....	1,094 27	.....	.....	.....	16,094 27
1867..	20,000 00	.....	7,608 38	.....	.....	.....	27,608 38
1868..	20,000 00	.....	592 49	.....	.....	.....	20,592 49
1869..	20,000 00	$30,000 00	17,559 00	$58 96	.....	.....	67,617 96
1870..	20,000 00	.....	1,320 02	2,720 93	.....	.....	24,040 95
1871..	18,250 00	10,500 00	4,135 72	3,785 54	.....	.....	36,671 26
1872..	18,250 00	3,000 00	217 05	7,175 65	.....	.....	28,642 70
1873..	21,796 00	15,602 00	10 13	11,059 06	.....	.....	48,467 19
1874..	13,000 00	15,602 00	150 13	14,061 98	.....	.....	42,814 11
1875..	7,638 00	7,755 50	144 53	14,446 14	.....	.....	29,984 17
1876..	7,638 00	6,755 50	1,773 09	16,830 17	.....	.....	32,996 76
1877..	6,150 00	30,686 80	979 06	15,172 86	.....	.....	52,988 72
1878..	6,150 00	5,686 80	826 60	15,807 09	.....	.....	28,470 49
1879..	4,971 80	16,068 32	712 22	16,978 22	.....	.....	38,730 56
1880..	4,971 80	7,068 32	797 55	17,837 24	.....	.....	30,674 91
1881..	7,249 00	43,720 50	461 95	20,935 25	.....	.....	72,366 70
1882..	7,249 00	8,945 50	358 46	22,507 45	.....	.....	39,060 41
1883..	8,385 00	23,793 00	391 95	30,749 60	.....	.....	63,319 55
1884..	8,385 00	10,526 00	1,259 90	27,909 72	.....	.....	48,080 62
1885..	.....	35,103 00	187 50	29,770 40	.....	.....	65,060 90
1886..	.....	22,617 00	.....	30,461 04	.....	.....	53,078 04
1887..	.....	*44,040 00	198 20	†24,611 37	.....	.....	68,849 57
1888..	.....	30,752 50	144 20	32,406 60	$15,000 00	.....	78,303 30
1889..	.....	*20,973 00	10 50	31,322 69	15,000 00	.....	67,306 19
1890..	.....	*27,172 00	238 50	32,360 64	15,000 00	$15,000 00	89,771 14
1891..	.....	22,947 50	37 38	34,750 54	15,000 00	16,000 00	88,735 42
1892..	.....	22,947 50	137 38	34,948 12	15,000 00	17,000 00	90,033 00
1893..	.....	18,862 50	10 50	37,927 04	15,000 00	18,000 00	89,800 04
1894..	.....	18,862 50	433 59	44,527 26	15,000 00	19,000 00	97,823 35
1895..	.....	‡19,000 00	10 50	45,301 85	15,000 00	20,000 00	99,312 35
1896..	.....	‡16,000 00	.....	43,886 40	15,000 00	21,000 00	95,886 40
1897..	.....	§17,700 00	.....	43,779 54	15,000 00	22,000 00	98,479 54
1898..	.....	‖17,500 00	.....	47,508 28	15,000 00	23,000 00	103,008 28
1899..	.....	¶8,750 00	705 00	52,526 11	15,000 00	24,000 00	100,981 11
1900..	.....	¶72,500 00	175 00	72,298 38	15,000 00	25,000 00	184,973 38
1901††	.....	¶72,500 00	.....	63,976 79	15,000 00	25,000 00	176,476 79
1902..	100,000 00	**1,000 00	.....	64,081 81	15,000 00	25,000 00	205,081 81
1903..	100,000 00	**1,000 00	.....	65,573 90	15,000 00	25,000 00	206,573 90
1904..	100,000 00	**1,000 00	61 19	67,312 37	15,000 00	25,000 00	208,373 50
1905..	100,000 00	*81,000 00	.....	72,035 32	15,000 00	25,000 00	293,035 32
1906..	157,810 00	*15,000 00	.....	70,286 56	15,000 00	25,000 00	284,096 56
1907..	173,410 00	**1,000 00	.....	70,155 22	23,691 60	25,000 00	293,256 82
1908..	173,410 00	**1,000 00	.....	70,385 79	23,326 10	30,000 00	298,121 89
1909..	173,410 00	**1,000 00	.....	69,527 13	26,000 00	35,000 00	304,937 13
1910..	173,410 00	**1,000 00	.....	71,109 49	28,000 00	40,000 00	313,519 49
Totals.	$1,613,533 60	$826,937 74	$101,723 66	$1,560,866 50	$386,017 70	$500,000 00	$4,989,079 20

*Including appropriation for weather service.
†October 1, 1886, to June 30, 1887, nine months.
‡Including $5,000 for institutes and $1,000 for weather service.
¶Including $5,500 for institutes and $1,000 for weather service.
‖Including $5,500 for institutes and $1,000 for weather service.
§Including $2,750 for institutes and $500 for weather service.
††To June 30. **Weather service.

SUMMARY OF INVENTORY, JUNE 30, 1910.

College farm and park, 671 acres		$67,100 00
Athletic field and drive, 13 acres		1,300 00
Buildings—		
Library and museum, built 1881	$22,000 00	
College hall, built 1856	17,000 00	
Wells hall, rebuilt 1905-06	55,000 00	
Williams Hall, built in 1869	30,000 00	
Abbot Hall, built 1888, addition in 1896	15,000 00	
Chemical laboratory, built 1871, south end addition 1881	18,000 00	
Machine shops and foundry, 1885, south end addition 1887	15,000 00	
Veterinary laboratory, built 1885	5,000 00	
Horticultural laboratory, built 1888	7,000 00	
Agricultural laboratory, built 1889, imp. 1897	7,500 00	
Botanical laboratory, built 1892	10,000 00	
Armory, built 1885	6,000 00	
Greenhouse and stable, built 1873, 1879, rebuilt 1892 and 1902	6,000 00	
Boiler house and chimney, built 1893-4	3,000 00	
President's and two frame dwellings, built 1874	12,000 00	
Six brick dwellings, built 1857, 1879 and 1884	18,000 00	
One frame house, built 1885	3,500 00	
Howard Terrace dwelling, built 1888	13,000 00	
Farm house dwelling, built 1869	2,000 00	
Herdsman's dwelling, built 1867	400 00	
Six barns at professors' houses	1,050 00	
Horticultural barn and shed, built 1868, 1875 and 1877	1,200 00	
Bull barn, rebuilt 1905	1,500 00	
Sheep barn, rebuilt 1906	2,500 00	
Horse barn, built 1906	5,000 00	
Grade herd barn, rebuilt 1905	4,000 00	
Piggery, rebuilt 1907	1,500 00	
Dairy barn, rebuilt 1900	4,000 00	
Farm mechanics building, built 1881	1,500 00	
Poultry house, built 1906	1,000 00	
Incubator house, built 1906	500 00	
Poultry house, built 1907	1,500 00	
Three poultry houses, built 1907	300 00	
Ten brooder houses, built 1908	250 00	
Corn barn, built 1878	400 00	
Stock judging barn, built 1894	200 00	
Brick work shop, built 1857	500 00	
Observatory, built 1880	100 00	
Bath house and fittings, built 1902-3	17,000 00	
Paint shop, rebuilt 1903	150 00	
Hospital, built 1894	3,000 00	
Postoffice and waiting room, built 1902	1,700 00	
Lumber shed, mechanical department	250 00	
Three silos	600 00	
Coal shed, built 1899	700 00	
Women's building, built 1900	91,000 00	
Dairy building, built 1900	15,000 00	
Bacteriological building, built 1902	27,000 00	
Power house, built 1904	25,000 00	
Amount carried forward	$473,800 00	$68,400 00

Amount brought forward	$473,800 00	$68,400 00
Coal shed, built 1905	6,500 00	
Tunnel system, built 1904	45,000 00	
Cold storage, rebuilt 1905	2,000 00	
Engineering building, built 1906-07, including heating	110,000 00	
Iron bridge over Cedar river, built 1888	1,500 00	
Bridge to athletic field	500 00	
Manure shed	600 00	
Four hospital cottages, built 1909	6,000 00	
Agricultural building, built 1909	182,000 00	
Addition to Botanical laboratory, built 1909	12,000 00	
		839,900 00
Heat, Light and Water Department—		
Instruments and furniture	$207 50	
Steam heating plant	15,890 00	
Bath house plant	698 00	
Water works plant	10,161 70	
Fire department	2,789 00	
Tools and fixtures	862 24	
Miscellaneous stock	4,663 98	
Electric light department stock	1,816 21	
Telephone department	3,511 71	
Plumbing stock	1,148 57	
		41,748 91
Agricultural Division—		
Department of Agricultural Education		443 32
Department of Animal Husbandry—		
Office library	$854 15	
Office	128 10	
Live stock	8,393 00	
Feed and miscellaneous	774 40	
		10,149 65
Department of Farm Crops		313 65
Department of Farm and Horses—		
Horses	$7,950 00	
Horse barn	1,310 89	
Corn crib	105 00	
Tool barn	1,703 88	
Office	334 20	
		11,403 97
Department of Farm Mechanics—		
Machinery and tools	$1,813 01	
Fittings	174 78	
Cement machinery	48 85	
Wood shop	623 73	
Blacksmith shop	1,081 62	
Office	165 69	
		3,907 68
Department of Forestry—		
Nursery stock	$8,517 30	
Forest products	144 80	
Office supplies	48 63	
Photographic materials	563 37	
Office furniture	446 85	
Nursery utensils	203 31	
Office equipment	65 00	
Laboratory supplies	134 67	
Camp equipment	261 00	
Books	609 20	
Exhibits	1,006 03	
		12,000 16
Amount carried forward		$988,267 34

Amount brought forward		$988,267 34
Department of Dairy Husbandry—		
Office	$462 50	
Live stock library	527 40	
Dairy live stock	7,249 00	
Feed	295 15	
Miscellaneous	68 00	
Dairy	1,365 30	
Dairy office	89 00	
		10,056 35
Office of Dean of Agriculture—		
Office	$565 69	
Class room furniture	1,594 00	
		2,159 69
Department of Horticulture—		
Heavy tools	$516 00	
Teams and harness	725 50	
Miscellaneous	866 12	
Tools	232 40	
Office	1,487 55	
Classroom	399 75	
Laboratory equipment	508 32	
Greenhouse plants	1,453 30	
Greenhouse tools	222 09	
Zoo	100 00	
		6,511 03
Poultry Department		2,309 55
Department of Soils—		
General	$2,262 63	
Photographic supplies	119 44	
Chemicals	20 64	
Furniture	418 93	
		2,821 64
Short Courses		1,499 30
Department of Veterinary Science—		
General operating instruments	$464 98	
Office furniture and fixtures	185 12	
Harness equipment	17 13	
Laboratory equipment	181 68	
Drugs and chemicals	7 48	
Classroom apparatus	1,188 28	
Department books	31 53	
		2,076 20
Division of Engineering—		
Department of Civil Engineering—		
Transits	$4,258 05	
Levels	1,852 30	
Sextants	230 55	
Compasses	835 20	
Hand levels	225 95	
Pocket compasses	51 25	
Computing instruments	537 85	
Time recorders	670 20	
Barometers and thermometers	274 70	
Current meters	193 65	
Plane tables	449 65	
Leveling rods and poles	507 05	
Steel tapes	297 50	
Chains	53 00	
Metalic tapes	81 28	
Linen tapes	19 20	
Amount carried forward	$10,537 38	$1,015,701 10

Amount brought forward	$10,537 38	$1,015,701 10
Division of Engineering—Continued.		
Miscellaneous surveying instruments	252 70	
Drawing instruments and materials	436 84	
Books and pamphlets	284 60	
Tools	59 22	
Miscellaneous apparatus	494 44	
Furniture and fixtures	3,401 38	
Hydraulic laboratory	1,529 65	
Cement laboratory	1,619 55	
Astronomical laboratory	414 45	
		19,030 21
Department of Drawing and Design		5,304 76
Department of Physical and Electrical Engineering—		
Motors and generators	$5,888 00	
Wattmeters	528 00	
Voltmeters	678 00	
Ammeters	602 50	
Starting boxes	113 00	
Transformers	1,118 00	
Rheostats	162 50	
Miscellaneous	1,123 87	
Shop and stock	551 06	
Furniture	2,838 43	
Mechanics	1,336 15	
Electricity and magnatism	4,330 97	
Light	1,481 45	
Sound	170 70	
Heat	427 80	
		21,350 43
Department of Mechanical Engineering—		
Office supplies and equipment	$8,725 18	
Experimental laboratory	12,535 72	
Machine shop	9,465 09	
Foundry	1,653 99	
Forge shop	1,859 84	
Woodworking machinery and tools	3,513 30	
		37,753 12
Division of Home Economics—		
Reception room and hall	$672 60	
Dean's office	197 25	
Day student's room	218 50	
Parlor	638 30	
Guest room	62 85	
Dormitory furniture	1,725 41	
Miscellaneous	129 20	
Recitation room	3 10	
Storeroom No. 33	25 29	
Dark closet	27 10	
Music rooms	2,461 50	
House library	99 95	
Gymnasium	366 14	
Gymnasium office	146 03	
Shower bath rooms	187 35	
Domestic science	889 19	
Domestic art	961 25	
Howard terrace	422 52	
		9,233 53
Amount carried forward		$1,108,373 15

Amount brought forward		$1,108,373 15
Division of Science and Letters—		
Department of Bacteriology—		
Literature	$76 78	
College chemicals	983 37	
College apparatus	7,918 36	
Fixtures and office supplies	834 02	
		9,812 53
Department of Botany—		
Garden tools	$64 80	
Herbarium	11,391 80	
Museum	830 00	
Books	750 95	
Photos and engravings	1,125 53	
Lantern slides	264 24	
Microscopes and accessories	1,598 00	
Glassware	605 61	
Chemicals, stains, reagents, etc	63 45	
Office and classroom equipment	939 30	
General equipment	195 95	
		17,829 63
Department of Chemistry—		
Cases and fixtures	$2,917 35	
Graduated glassware	1,344 78	
Ungraduated glassware	5,221 67	
Organic chemicals	465 00	
Inorganic chemicals	896 81	
Electrical apparatus	974 73	
Special apparatus	3,195 35	
Gas analysis apparatus	165 00	
Platinum	2,044 42	
Mercury	21 25	
Balances	1,797 00	
Weights	797 70	
Metals	45 74	
Rubber	171 29	
Specimens and mineralogical supplies	586 72	
Porcelain	871 05	
Hardware	1,337 39	
Tools	64 90	
Woodenware	309 20	
Assay room supplies	214 54	
Miscellaneous	375 29	
		23,817 18
Department of English		725 44
Department of Entomology—		
Furniture and collections	$4,071 47	
Apparatus	691 42	
Books	141 79	
Supplies	299 23	
		5,203 91
Dept. History and Economics		484 40
Department of Mathematics—		
Office furniture	$196 95	
Books	44 58	
		241 53
Department of Military Science and Tactics—		
Military equipment	$898 50	
Band properties	77 75	
		1,674 25
Amount carried forward		$1,168,162 02

Amount brought forward		$1,168,162 02
Department of Physical Culture and Athletics—		
Armory and gymnasium	$453 00	
Bath house	40 40	
Office	201 00	
Field	133 10	
		827 50
Department of Zoology and Physiology—		
General museum	$18,868 00	
Furniture and apparatus	1,836 09	
Dissecting instruments	50 00	
Drawing instruments and materials	10 90	
Geological	243 79	
Microscopic	2,276 20	
Photographic	225 15	
Tools	59 28	
Miscellaneous	497 90	
		24,067 31
Carpenter shop		725 20
Cleaning		447 13
Farmers' Institutes Department		522 27
Hospital		261 93
Hospital cottages		611 75
Library		57,813 88
Department of Nursery and Orchard Inspection		80 43
Office of Registrar		333 30
Paint shop		646 28
President's office		873 58
Secretary's office		2,178 79
Miscellaneous		4,214 95
Weather Bureau		1,344 57
Total		$1,263,110 89

SUMMARY OF EXPERIMENT STATION INVENTORY.

Lands donated to the Station—		
80 acres at Grayling, fenced and improved at cost	$1,000 00	
5 acres at South Haven, fenced and improved	1,000 00	
160 acres at Chatham, including buildings	4,000 00	
		$6,000 00
Buildings—		
Bacteriological stable	$3,700 00	
Experiment station feed barn	800 00	
Veterinary laboratory, experimental rooms	250 00	
House	1,000 00	
Station Terrace building	3,000 00	
Seed room	500 00	
Slaughter house	625 00	
Storage barn	600 00	
Insectry	1,000 00	
		11,475 00
Experiment Station—		
Division of Bacteriology—		
Literature	$1,633 04	
Chemicals	652 63	
Apparatus	8,467 39	
Fixtures and office supplies	229 63	
		10,982 69
Division of Botany—		
Books	$15 80	
Glassware	43 38	
Chemicals	9 06	
Furniture	74 00	
Sundries	36 69	
General apparatus	206 62	
Miscellaneous	18 12	
Plants	344 00	
Microscopes, etc	320 62	
Photographic apparatus	183 79	
		1,252 08
Division of Chemistry—		
Chemicals	$420 01	
Glassware	1,045 11	
Porcelain ware	85 44	
Sampling material	188 08	
Office furniture and supplies	393 12	
Miscellaneous	2,970 33	
Tools	28 09	
		5,130 18
Farm Division		1,392 04
Division of Entomology—		
Furniture	$500 53	
Supplies	46 44	
Miscellaneous	1,762 58	
Books	711 70	
Apparatus	629 35	
Chemical supplies	214 24	
Amount carried forward	$3,864 84	$36,231 99

Amount brought forward	$3,864 84	$36,231 99
Photographic supplies	411 05	
Supplies	147 92	
Glassware	430 87	
Chemicals	185 87	
Stains	13 91	
Spray machinery	52 70	
Tools	19 82	
Sundry	94 12	
		5,221 10
Division of Horticulture		871 05
Library		4,703 50
Director's office		409 10
Bulletin room		425 76
Division of Soils		591 31
South Haven Experiment Station		256 15
Upper Peninsula Experiment Station		2,016 64
Total		$50,726 60

REPORT OF THE PRESIDENT.

To the Honorable State Board of Agriculture:

Gentlemen: There is submitted herewith the annual report of the Michigan Agricultural College for the year ending June 30th, 1910, in compliance with the provisions of the statutes. The accompanying reports of the deans and the heads of departments of the college set forth quite clearly the work of the year, and the careful attention of the members of the Board is invited to the various suggestions and recommendations which this report contains.

The year was one of substantial progress. There was nothing unusual to interfere with the natural and consistent work of the institution. The increase in attendance over the previous year was about 11%. The total number of students enrolled was 1494. There has been from year to year a gradual advancement in the standard of preparation of the entering classes. Each year a larger percentage classify for entrance to our four year courses and those entering our five year courses are of a higher grade than of the previous year. It would seem that we are rapidly approaching the time when it will not be necessary to maintain longer our five year courses. It is certainly not our intention to compete with the high schools of the state. The object of our five year courses is to give young people who have failed to complete a high school course, and later in life desire to prepare for college, an opportunity to do so. The reasons for offering this preparatory work at the college are becoming less urgent each year and it is apparent that before long the five year courses may be abandoned without material injury to any considerable number.

The graduating class this year numbered 92. Forty completed the engineering course, 17 the home economics course, 24 the agricultural course and 11 the forestry course. Advanced degrees were conferred in accordance with the regulations laid down by the Board as follows:

Charles H. Alvord, M. Agr.; Arthur Charles Dodge, C. E.; Joseph Philip Haftencamp, C. E., Simon B. Hartman, M. Hort.; Charles Philo Reed, M. Agr.; Frank Curtis Rork, C. E., William F. Uhl, C. E.

The baccalaureate sermon was delivered on the afternoon of June 19th, in the armory, by Rev. Charles H. Beale, D. D., of Milwaukee, Wisconsin. Dr. James B. Angell, President Emeritus of the University of Michigan gave the commencement address on June 21st. It is worthy of note that Dr. Angell delivered the commencement address at this institution in 1871, thirty-nine years ago. It is needless to say that his address was of much more than usual interest and was enjoyed by a large and appreciative audience.

The triennial reunion of alumni was held this year. The principal

addresses were given by the Hon. Charles W. Garfield, '70, and the Hon. William L. Carpenter, '73. The banquet, which was held in the pavilion of the new agricultural building, was attended by about five hundred alumni.

CHANGES IN FACULTY.

Dr. William James Beal, who has been in charge of the Department of Botany for forty years, requested that he be permitted to retire from active service at the end of the year. He is still retained as Professor Emeritus and will be privileged to do such research work as may suit his pleasure.

Dr. Beal retires with unimpaired mental and physical vigor. Although past seventy-seven years of age, he has, of his own choice, carried full work in his department with his accustomed energy and ability. The value of Dr. Beal's life work as a teacher and scientist will, no doubt, be set forth clearly and properly in due time. However, his department which has attained such high rank, bears testimony to his persistence and love of toil. His life and work has always been an inspiration and example to young teachers. He spent little time behind a roll-top desk. He never requested nor expected to be relieved of the greater part of his teaching because of the executive duties of his department. It would astonish many young teachers to know the actual number of hours that Dr. Beal has spent in classroom, herbarium or botanic garden during each week. It is a pleasure to note that by following simple methods of living he has been able to retain, to this advanced age, his remarkable physical and mental equipment.

When he entered upon his work at this college, he did considerable teaching in addition to that of botany. During these years, his department has grown and developed until at the present time the Department of Botany occupies its own building of more than twelve rooms. It contains a finely selected and carefully preserved herbarium of about one hundred six thousand specimens, and a botanical garden which has been mentioned as one of the three best in this country connected with educational institutions. It occupies two and one-tenth acres of land and contains twenty-one hundred species.

For many years, Dr. Beal also had charge of the forestry work of this institution. He planted an arboretum thirty-three years ago containing one hundred fifty varieties of trees.

It would take many pages to set forth, even in a brief form, the great work he has accomplished. We shall leave that for the present to the hands of others.

Dr. Ernst A. Bessey has been selected to fill the position vacated by Dr. Beal. Dr. Bessey has had exceptionally thorough training and has successfully filled the chair of botany in the Louisiana University, resigning this position to accept the professorship of botany in this college.

As usual, a number of subordinate teachers resigned during the year. There has been such a demand for trained men in engineering and agriculture that it has been very difficult to retain energetic, capable men as instructors.

ESTABLISHMENT OF VETERINARY DIVISION.

For a number of years considerable pressure has been brought to bear upon the State Board, by the live stock interests of the state and by the state veterinary associations, to establish a well equipped veterinary school at this institution. The Board finally acceded to this demand and has organized a veterinary division which will prepare young men to practice the profession of veterinary medicine.

The standard for entrance will be the same as the standard for entrance to the agricultural course. The veterinary students will receive the same instruction through the freshman year and part of the sophomore year as is given to the agricultural students. Beginning with the second term of the sophomore year, the veterinary students will be given largely technical work through the remainder of the course. This course will be four years in length and will meet all the requirements laid down by the national Department of Agriculture. It is the purpose to maintain a school of veterinary science which will be of equal rank with the very best institutions of this kind in the country.

Dr. Richard P. Lyman has been placed in charge of this division of the college as dean. He is a graduate of the Massachusetts Agricultural College and also of the Harvard Veterinary School. After practicing his profession for seventeen years, he accepted a professorship in the Kansas City Veterinary College. After several years of successful teaching he has been induced to enter the service of the institution. Dr. Lyman will take up his work at the opening of the next college year.

EXTENSION WORK.

The rapid advance in the prices of all farm products within the last two or three years has given a great impetus to the farming industry. Farmers have not for many years, if ever before, received as high prices for their products as they are receiving at the present time. The causes leading to this advancement in prices seem to be natural. Consumption is rapidly overtaking production. Our public domain is almost exhausted—hence, we must look to the land now under cultivation for the additional provisions necessary to take care of the rapidly increasing population. Farming as a business is on the upward trend. Farmers are rapidly lifting their mortgages, making improvements and accumulating a surplus.

This onward movement is laying new responsibilities upon the college. Not only are more young men coming to the college to study agriculture, but there is an increasing demand for the professors of the college to carry the instruction to the farmers. We now have three men who give practically all their time to the farmers of the state. We could keep perhaps ten men busy. The demand is becoming more persistent each year. It would seem wise, if the college had the money, to organize as soon as possible traveling schools which would hold a session from one to two weeks in length in each county of the state. Nothing less than this will meet the demands of the people. The state should be urged to furnish the funds for carrying on this work. There was a bill before Congress last year to grant funds to the agricultural colleges for this purpose. It is probable that within a few years the national govern-

ment will assist the states in carrying on extension work of this nature, but our state cannot afford to wait. Michigan has always been in advance of the government aid. Our college preceded the act of Congress which made possible such institutions in other states. For many years, this college carried on experiments and published bulletins before the Hatch Act was passed by Congress which made possible our great system of experiment stations. Would it not be wise for the state to grant the aid necessary to carry out to the people the results of the educational and experimental work of the college?

BUILDINGS.

I wish to repeat my recommendation of last year concerning the urgent necessity of a library building and auditorium. We need other buildings—a gymnasium, an addition to our women's building, an addition to our chemical building, a veterinary building, etc., but the greatest demand is for a building which will accommodate our library and executive offices and provide an auditorium. It should be a large central building.

The college has an exceedingly valuable library. If it should be destroyed, many of the books could not be replaced. We have not room enough for anything like all our books. We have been compelled to store many of them in other buildings. Our reading room and library tables accommodate but a very small proportion of our students. In short, our library facilities, to say nothing of the great risk of losing all our books by fire, are entirely inadequate. We cannot afford to take the risk of keeping such a valuable collection in a building which is liable to go up in flames at any time.

The demand for an auditorium is almost as great. Our chapel, which is our accustomed place of meeting, does not hold one-fourth of the student body. Our armory, which is used on special occasions as an auditorium, is not large enough to seat much more than one-half of the students and faculty. In addition to this the armory is used for military purposes, and when it is used as an auditorium, the military drill is interfered with and it is made ready for a general meeting at considerable expense. It is to be hoped that funds may be available in the near future for the erection of a building which will relieve the present congested condition.

I herewith submit the usual statistics concerning the last entering class.

NAMES OF GRADUATING CLASS.

The names and addresses of those receiving degrees are as follows:

(Students in Agriculture are designated by *a*; Engineering by *e*; Home Economics by *h*; Forestry by *f*.)

Name.	Postoffice.	County.
Babcock, MacLean Morton, *e*	Saugatuck	Allegan.
Bair, Mary Blanche, *h*	St. Johns	Clinton.
Bangs, Nellie, *h*	Lansing	Ingham.
Barcroft, Glenn Asbury, *e*	Freeport	Barry.
Bates, Wilhelmina Ruth, *h*	Hastings	Barry.
Benedict, Leroy Lowell, *e*	Lansing	Ingham.
Benham, Catherine Francis, *h*	Milford	Oakland.
Bidwell, John Northrup, *e*	Allegan	Allegan.
Brown, Edward Lakin, *a*	East Lansing	Ingham.
Burkhart, Glen Pulver, *e*	Fowlerville	Livingston.
Burt, Thomas, *a*	Redford	Wayne.
Bushnell, Elwood Perry, *f*	Bronson	Branch.
Campbell, Arthur Lawrence, *a*	Cheat Haven	PENNSYLVANIA.
Cataline, Benton, *e*	Whittemore	Iosco.
Cavanagh, Gordon, *e*	Mt. Pleasant	Isabella.
Chapin, Julius William, *a*	Eden	Ingham.
Clark, Katherine G, *h*	Dewitt	Clinton.
Clippert, Clarence Grover, *a*	Detroit	Wayne.
Cools, Remie, *e*	Detroit	Wayne.
Copson, Florence Ethel, *h*	Grand Rapids	Kent.
Crane, Ray George, *a*	Owosso	Shiawassee.
Dail, Elmer Ray, *e*	Lansing	Ingham.
Darling, Frank Wilson, *f*	Almont	Lapeer.
DeCamp, John Conely, *f*	Lansing	Ingham.
Dougherty, Lloyd Weld, *e*	Three Rivers	St. Joseph.
Douglass, Howard Higby, *a*	Lansing	Ingham.
Egerton, Bertram Gallaway, *e*	Twining	Arenac.
Emery, Helen, *h*	Lansing	Ingham.
Farmer, Max Daniel, *e*	Lansing	Ingham.
Ferguson, Mildred Grace, *h*	Haslett	Ingham.
Fraser, Harry Roderick, *e*	Flint	Genesee.
Gilson, Irving, *f*	Deerfield	Lenawee.
Hagenbuch, Samuel Chas., *a*	Three Rivers	St. Joseph.
Hallock, Eugene DeForest, *e*	Niles	Berrien.
Harrison, Florence Fern, *h*	Milford	Oakland.
Hobbs, George William, *e*	Minden City	Sanilac.
Hodgman, Claude Leroy, *e*	Gobleville	Van Buren.
Hoffman, Bruce Earl, *f*	Goodrich	Genesee.
Hoffman, Ernest Glen, *e*	East Lansing	Ingham.
Hooper, Thomas Milton, *e*	Victoria	Ontonagon.
Hopkins, Ralph Zublin, *e*	Detroit	Wayne.
Hurd, Albert Lee, *a*	Gagetown	Tuscola.
Johnson, Minnie Esseline, *h*	Grand Rapids	Kent.
Johnston, Max Lockwood, *a*	Linden	Genesee.
Jordan, Thomas Andrew, *e*	Morrice	Shiawassee.
Kurtz, Edward Ezra, *e*	Blissfield	Lenawee.
Lambert, Georgiana Ruth, *h*	Niles	Berrien.
Lawrence, Oliver Cook, *a*	Hudson	Lenawee.
Lemmon, Charles Alex., *e*	Lansing	Ingham.
Lynch, Hugh Edward, *f*	Grand Rapids	Kent.
McKenna, Parnell Gladstone, *e*	Quinnesec	Dickinson.
McLachlan, Ira D., *e*	Sault Ste. Marie	Chippewa.
Mason, Clark D., *a*	Kalamazoo	Kalamazoo.
May, William Gilbert, *e*	Stockbridge	Ingham.
Mead, Lynn DeCoursey, *e*	Hastings	Barry.
Miller, Alonzo McClair, *e*	Howard City	Montcalm.
Miller, John Philip, *a*	Rochester	NEW YORK.
Mills, Herbert Wade, *e*	Adrian	Lenawee.
Moore, Clyde Dell, *e*	Freeport	Barry.
Olin, Harry, *f*	Okemos	Ingham.
Perrine, Arthur Hough, *a*	Jackson	Jackson.
Perry, Carl VanAnde, *e*	Charlotte	Eaton.
Piper, Philip Henry, *e*	East Lansing	Ingham.
Ponitz, Charles Henry, *e*	Hudsonville	Ottawa.
Pulling, Arthur Presswood, *e*	Parma	Jackson.
Rodegeb, Eli, L., *a*	East Lansing	Ingham.
Rogers, Mabel Claire, *h*	Lansing	Ingham.
Sargeant, Arthur Herbert, *e*	Detroit	Wayne.
Shaw, James Eugene, *e*	Homer	Calhoun.
Shaw, James Lester, *e*	Harbor Springs	Emmet.

Names of graduating class.—Concluded.

Name.	Postoffice.	County.
Smith, Claude Edmund, *a*	Merle Beach	Clinton.
Smith, John Andrew, *a*	Howell	Livingston.
Snow, Oren Leone, *e*	Lansing	Ingham.
Spratt, Winfield Chester, *a*	Alpena	Alpena.
Stolte, Clara Alma, *h*	Lansing	Ingham.
Taft, Hazel Charlotte, *h*	East Lansing	Ingham.
Taggett, Vernon Newton, *e*	Caro	Tuscola.
Taylor, Robert Lochead, *a*	Lapeer	Lapeer.
Thome, William Joseph, *c*	Detroit	Wayne.
Thompson, Robert Elmer, *f*	Grand Rapids	Kent.
Turner, Ray A., *a*	Evart	Osceola.
Twiggs, Muriel, *h*	Detroit	Wayne.
Van Heulen, Barbara, *h*	Grand Rapids	Kent.
Vedder, Norma Dodd, *h*	East Lansing	Ingham.
Voorhorst, Ray Gordon, *a*	Leroy	Osceola.
Wagner, Chester Stanley, *f*	Port Huron	St. Clair.
Wagner, George Clinton, *a*	Colon	St. Joseph.
Waldron, James A., *a*	Tecumseh	Lenawee.
Wheeler, Ray Spencer, *f*	Athens	Calhoun.
White, William Emby, *f*	Coldwater	Branch.
Whitney, J. Logan, *a*	Jamestown	Ottawa.
Wilcox, James Edward, *c*	Ceresco	Calhoun.

COUNTIES REPRESENTED IN ENTERING CLASS.

Alger	2	Kalamazoo	3
Allegan	10	Kent	39
Alpena	4	Lapeer	2
Antrim	6	Leelanau	3
Arenac	1	Lenawee	6
Barry	4	Livingston	5
Bay	4	Mackinac	1
Benzie	2	Macomb	5
Berrien	21	Manistee	4
Branch	2	Marquette	8
Calhoun	11	Mason	3
Cass	2	Mecosta	1
Charlevoix	1	Monroe	2
Cheboygan	1	Montcalm	4
Chippewa	3	Montmorency	1
Clare	2	Muskegon	3
Clinton	7	Newaygo	2
Dickinson	3	Oakland	10
Eaton	3	Oceana	4
Emmet	9	Osceola	6
Genesee	13	Otsego	2
Gogebic	4	Ottawa	13
Grand Traverse	9	Roscommon	1
Gratiot	1	Saginaw	10
Hillsdale	9	Sanilac	5
Houghton	4	Shiawassee	6
Huron	7	St. Clair	9
Ingham	70	St. Joseph	3
Ionia	5	Tuscola	3
Iosco	2	Van Buren	4
Iron	1	Washtenaw	2
Isabella	1	Wayne	38
Jackson	5	Wexford	5

Other States and Countries represented.

Alabama	1	Missouri	1
Arkansas	1	Montana	1
California	1	New Jersey	3
Connecticut	2	New York	19
Egypt	1	Ohio	14
Florida	1	Oklahoma	1
Illinois	10	Ontario	2
Indiana	7	Pennsylvania	4
Maryland	1	South Dakota	2
Massachusetts	5	Russia	1
Mexico	3	Vermont	1
Minnesota	1		

SUMMARY OF STUDENTS.

	Agricultural.	Engineering.	Home economics.	Forestry.	Totals.
Post Graduates	3	.....	5	.....	8
Class of '10	29	48	18	12	107
Class of '11	38	74	27	22	161
Class of '12	95	120	51	.....	266
Class of '13	151	172	89	.....	412
Sub-Freshmen	75	81	32	.....	188
Special Students	52	5	14	2	73

	General Agric'l.	Creamery.	Poultry.	Fruit.	Cheese.	Summer course.				
Special Short Course Students	167	46	10	32	4	28	287	.....	.....	.....	287
Totals							730	500	236	36	1502
Deduct names repeated							.....	.....	.....	.....	8
Net total							.....	.....	.....	.....	1494

J. L. SNYDER, President.

REPORT OF THE DEAN OF AGRICULTURE.

To President J. L. Snyder:

During this year a reorganization was effected by which the Agricultural Department was replaced by seven distinct departments under the following designations, viz., Farm Crops, Soils, Animal Husbandry, Dairy Husbandry, Farm and Horses, Poultry, and Farm Mechanics. The work of the old department had become so comprehensive that a division of responsibility became very urgent. The new form of organization permits of concentration of effort on the part of those in charge, resulting in specialization and the exercise of specialized effort toward industries in the state of sufficient importance to warrant this action.

A number of changes took place in the personel of the staff of the Agricultural Division. Mr. L. J. Smith, instructor in charge of farm mechanics resigned early in the year to accept a similar position at the Manitoba Agricultural College and was succeeded by H. H. Musselman, an engineering graduate of M. A. C. in 1909. Mr. H. L. Kempster, one of our agricultural graduates of '09, was selected to succeed Mr. Jas. G. Halpin who was appointed Poultry Husbandman at the Uni-

versity of Wisconsin. Professor H. W. Norton, Jr., resigned to return to the farm in Livingston county and G. A. Brown was placed in charge of the Animal Husbandry department, in the position of instructor. Mr. C. H. Spurway was selected for the position of instructor in the Soils department. In February, 1910, Mr. V. M. Shoesmith was appointed Professor of Farm Crops, thus completing the reorganization. The manner in which the responsibility has been assumed by the newly appointed men has been gratifying indeed and the future would seem to give promise of good results if the present organization can be continued unbroken.

After the resignation of Dr. L. M. Hurt, in charge of the Veterinary department, which took effect December 30, 1909, the regular and short course veterinary subjects were presented by Dr. G. A. Waterman during the months of January and February. The year's work was completed very satisfactorily by Dr. Ward Giltner through the courtesy of the Bacteriological department.

The college year has been an unusually prosperous one. The number of students enrolling in agriculture and forestry is constantly increasing. The occupation of the new agricultural building at the beginning of the winter term presented facilities, particularly in the form of laboratories, which permit the course in agriculture to be prescribed in a manner satisfactory to the most rapid and efficient progress of the student and also to the satisfaction and comfort of the instructor. Of this year's graduating class, those who specialized in agriculture returned to the farm with few exceptions, and in these cases the young men did not have farms to return to. This is all the more remarkable in view of the fact that the demand for young men to fill positions during the year has been greater than ever before.

The following figures include a statement of the total enrollment of students in agriculture and forestry during the year, including regular, special and short course students, viz.:

Students Enrolled in Four and Five Year Courses and as Specials.

Post Graduates	3
Seniors	41
Juniors	60
Sophomores	95
Freshmen	151
Sub-freshmen	75
Special students	54
Total	479

Special Short Course Students.

General agriculture, first year, eight weeks	127
General agriculture, second year, eight weeks	40
Creamery, first year, six weeks	42
Creamery, second year, six weeks	4
Poultry, eight weeks	10
Fruit, four weeks	32
Total	255

One Week Farmers' Courses.

Corn production	32
Dairy	65
Swine	10
Total	107

The sum total enrolled in the three types of courses in agriculture and forestry throughout the year amounts to 841, not including the summer school for teachers.

The short courses this year were unusually successful. Neither disease nor misfortune interfered in any way and the enrollment remained practically unbroken until the courses were completed. The previous preparation of the young men was a notable feature; not less than 75% of those enrolled in the first year general agriculture had attended high school, many having completed the course. With the exception of a very few, the short course men returned to the farms.

PROGRAM OF THE FARMERS' ONE WEEK COURSES.

These courses will offer one week's work in each of the above subjects. They are intended for men that are actually engaged in business and twenty-five years of age or older. The courses are offered to give the busy man, confined by responsibilities, an opportunity to get in touch with the most recent developments along scientific and practical lines in relation to his special business. It will afford a very desirable relaxation, for a few days at least, from the routine of farm life. The association with numbers of other men with common interests and the personal contact with educational features and influences surrounding a large educational institution cannot do otherwise than to arouse renewed interest and impart a new stimulus to the individual upon the return to his special vocation. The work will be presented by able specialists in addition to college men, and a special effort will be made to bring out discussions and results from the personal experience of the individual.

Each of these one week courses will deal with a specific line of work. Those who desire may take one, or more, or all of them. An enrollment fee of $1.00 will be required at the time of registration. This fee will be good for one week or for the entire four weeks.

The corn work will begin February 14th; Round-up Institute February 22 to 25th; the Dairy week February 28th; the Swine week March 7th. With the exception of the Round-Up Institute, these courses will begin at noon on the dates named and continue until the following Saturday noon.

Corn Week, Feb. 14-19.

The following subjects will be presented and discussed.

(1). Soils, preparation, planting, cultivating and corn cutting implements, fertilizers.

(2). Corn improvement, possibilities, seed selection, breeding, commercial seed production, Michigan weeds, chemistry of corn and corn products.

(3). Harvesting and marketing, general methods, details of methods, huskers, shredders, etc., marketing and shrinkage and enemies.

(4). Corn judging—ideal ear, methods and terms, score card relation to improvement.

Two or three hours daily will be devoted to corn judging.

Dairy Week, Feb. 28-Mar. 5.

This course will include the following:

(1). Studies in breed type with animals for demonstration and criticism, scoring, etc. The actual judging of rings of animals will be included.

(2). Dairy cattle feeding.

(3). Dairy cattle breeding problems.

(4). Private, semi-official and official tests.

(5). Babcock test and cream separators.

(6). Tuberculin testing.

(7). Emergencies.

(8). Equipment.

Swine Week, Mar. 7-12.

The following outline is presented:

(1). Studies in breed type.

(2). Swine judging.

(3). Breeding.

(4). Feeding.

(5). Forage crops.

(6). General diseases and sanitation.

(7). Equipment.

THE NEW AGRICULTURAL BUILDING.

In preparing plans for this building the main object sought was to procure a massive, plain, impressive, useful structure. The contract was let and the work begun early in April, 1908. The building was occupied a week or two before the beginning of the calendar year, 1910.

The building has four stories and a basement which is in reality a half-basement. There is a total frontage of 190 feet and the wings are 110 feet from front to rear, while the stock-judging pavilion extends 70 feet back beyond the wings.

The structure is faced with Indiana limestone up to the first floor after which it is finished with a dark red paving brick. The building is of fireproof construction, consisting of concrete reinforced with steel. The only wood used is that necessary in finishing, such as door and window cases and office and classroom flooring, in addition to the roof. Maple flooring was used and all other finishing material is of oak with a dull wax finish. Except the basement floors, which are of cement, all the halls including the wainscoting four feet high are floored with a composition material, somewhat resembling cement, now used as a substitute for tile.

The wings of the building except for one or two floors, as well as the main portion, are subdivided by halls running to the outer walls, thus

admitting an abundance of light. The stairways are of reinforced concrete construction with slate treads protected by iron banisters capped with mahogany rails.

One of the most satisfactory features about the building is the perfectness of the lighting, of which there is a great abundance as indicated in the illustration showing the front elevation. The artificial lighting has been well provided for by tungsten lamps which have been installed.

Heat is supplied directly from the power plant to radiators in the various rooms with a total radiating surface of 8,325 square feet. In case of need this can be supplemented by the addition of warm air circulated by the fan after passing through steam coils. The temperature is regulated by the thermostadts. The ventilating system is both direct and indirect, on the one hand dependent on a system of flues and on the other controlled by the fan.

Before it was decided to use the fireproof construction, six vaults were included in the plans, three in each end of the main portion of the building, accessory to the offices of the various department heads. These are proving a great convenience in caring for records and experimental data of unusual value.

Two elevator shafts were built and an electric elevator installed in one of them. This has proved to be a convenience of exceptional value in handling materials of all kinds and in meeting the needs of those using classrooms on the upper floors and for entertainments and meetings in the assembly room on the top floor.

The office desks, chairs, bookcases, tables, etc., are alike throughout the building and are of oak finished to match the woodwork. These fixtures are of a plain, substantial, useful type.

GROUND FLOOR.

The ground floor, which is a one-half basement, contains the following rooms, viz.: Room number 10, 14x17 ft., consists of a toilet room for men. Room 11, 16x16 ft., is fitted with grinding, mixing and sampling appliances used by the Soils and Chemical departments in the preparation of soils and fertilizers, feed stuffs and other materials for laboratory uses. The machinery is operated by an electric motor. Room 12, 32x41 ft., is a demonstration class room, seating 100, and is used in connection with carcass and meat cut studies in meat production. Room 13, 23x24 ft., is the laboratory in which meat cutting is carried on in determining the percentages, quality and comparative values of the various cuts of the animal carcass. This room is furnished with meat blocks, tables, benches, racks, etc. Room 14, 19x24 ft., was to have been furnished with cold storage equipment but the plans have been changed and an artificial refrigeration system will be installed. Steel track for the removal of meat carcasses extends from this room through 13 and across the hall into 14. Room 15, 13x24 ft., is fitted with shelves and stacks used for the storage of bulletins and reports. Room 16, 45x120 ft., is the stock-judging pavilion. There are raised seats in each end accommodating 90 students. In the center there is a steel screen which can be raised or lowered at will dividing the room into two parts, each of which is provided with doors for the admission of live stock.

The lighting is perfect and the acoustic properties of the room are good. The floor is of exceedingly hard clay which is kept covered with planer shavings. This room with the gallery above has seated 1,200 people and could be made to accommodate at least 300 more. Though this room was in constant use during the winter term, it was cared for in such a way as not to bear the slightest resemblance to the barnyard in appearance or the least taint of the cow stable so far as odors were concerned. In fact, this room has been the center of interest since the opening of the building so far as notable events are concerned. Since the opening of the building the following functions have been held in the pavilion, viz.: The athletic association circus, state oratorical contest, intercollegiate debate, May festival and the triennial alumni banquet. Room 17, 58x68 ft., is used by the Farm Mechanics department. Here, representative farm machinery, in operation, is studied by the student in addition to a part of the instruction work in power machinery. This room is four feet deeper from ceiling to ground than the rest of the floor. Room 18, 30x45 ft. is fitted for instruction work in concrete manufactures such as tile, culverts, posts, troughs, building and silo blocks, etc. Room 19, 20x32 ft., contains the motor and fan controlling the ventilation of the building and also furnishing auxiliary heat when needed. Room 20, 14x20 ft., is the office of the farm superintendent and Room 21, 16x20 ft., that of the instructor in charge of farm mechanics. Room 22, 16x30 ft., is used by the bulletin mailing clerk of the Experiment Station. Room 23, 29x29 ft., remains unassigned; it is suitable for either laboratory or lecture purposes and has been furnished with sixty removable tablet arm chairs, six closets and small storerooms are available from the hallway of this floor.

FIRST FLOOR.

This floor contains the largest percentage of office space, comprising the entire front with the exception of one room. It also has eight class rooms with a total seating capacity of 513, of which 465 are permanently fastened to the floors.

The following are the dimensions of seven class rooms with the numbers of permanent seats, viz.: 100, 28x32 ft., has sixty-three seats; 102, 24x26 ft., forty-two seats; 103, 22x24 ft., forty-two seats; 109, 34x48 ft., one hundred forty-four seats; 110, 24x29 ft., forty-eight seats; 111, 24x27 ft., fifty-six seats; number 116, 21x31 ft., has forty-eight removable tablet arm chairs. This room was not permanently seated thus permitting its division into two rooms for offices as future needs increase.

The small rooms 104, 105, 107 and 108 are used for storage for janitor supplies and illustrative materials for adjacent classrooms. Number 106 comprises the balcony of the stock-judging pavilion several feet below the level of the first floor. It is eight feet wide at the end nearest the entrance and four feet in width on the other three sides. A magnificent view of the live stock classes, while in progress, may be obtained from the large hall windows.

Room 112, 12x16 ft., is the outer office of the Dairy Husbandry department with vault and toilet facilities adjacent while 112-1, 14x16 ft., is the private office of the head of the department. Room 112-2, 17

x18 ft., is the herd-book library with storage room, available to the live stock departments on both sides. Room 113, 12x24 ft., is the office of the Animal Husbandry department, having cloak and toilet rooms adjacent.

Room 114, 14x15 ft. not including cloak or toilet rooms, is occupied by the department of Agricultural Education. Number 115, 16x19 ft., comprises the office of the Poultry department. These two latter rooms as well as 116 open out on the balcony thus furnishing a magnificent frontage.

On the northwest corner is located the office quarters of the Dean and Director. At the present time, 117, 16x30 ft., is being occupied by the Registrar of the college. Room 118, 12x14 ft., with vault adjacent is the outer office of the Dean and Director, 118-1, 14x14 ft., is the private office and 118-2, 14x19 ft., the file and record room.

SECOND FLOOR.

As in the case of the first floor, the front of the second is largely fitted for offices. The northeast wing is used exclusively for soils laboratories and the northwest one for classrooms.

Rooms 201 and 202 are of equal size, 33x45 ft., and both are fitted alike for laboratory work in soils, the total capacity of the two accommodates ninety-six students at one time. Room 200 is used as a stock room for laboratory equipment while 203 furnishes storage for laboratory materials in addition to pulverizers and drying ovens. For more detailed description see report of Soil Physicist, page 53.

The classrooms 206, 207 and 208 are exactly the same in size, seating and all other respects as 109, 110 and 111, in the order named and heretofore described, on the first floor. The small rooms 204 and 205 were designed for storage purposes.

Room 209, 12x13 ft., comprises the outer office of the Professor of Soils and Soil Physics and 209-1, 15x16 ft., the private office. Room 210, 20x 30 ft., is an experimental and advanced students laboratory. This department suite also has small rooms for weighing apparatus, storage, toilet facilities and vault space.

Rooms 211 and 212 both approximately 16x20 ft. are being occupied as offices for the department of History and Economics.

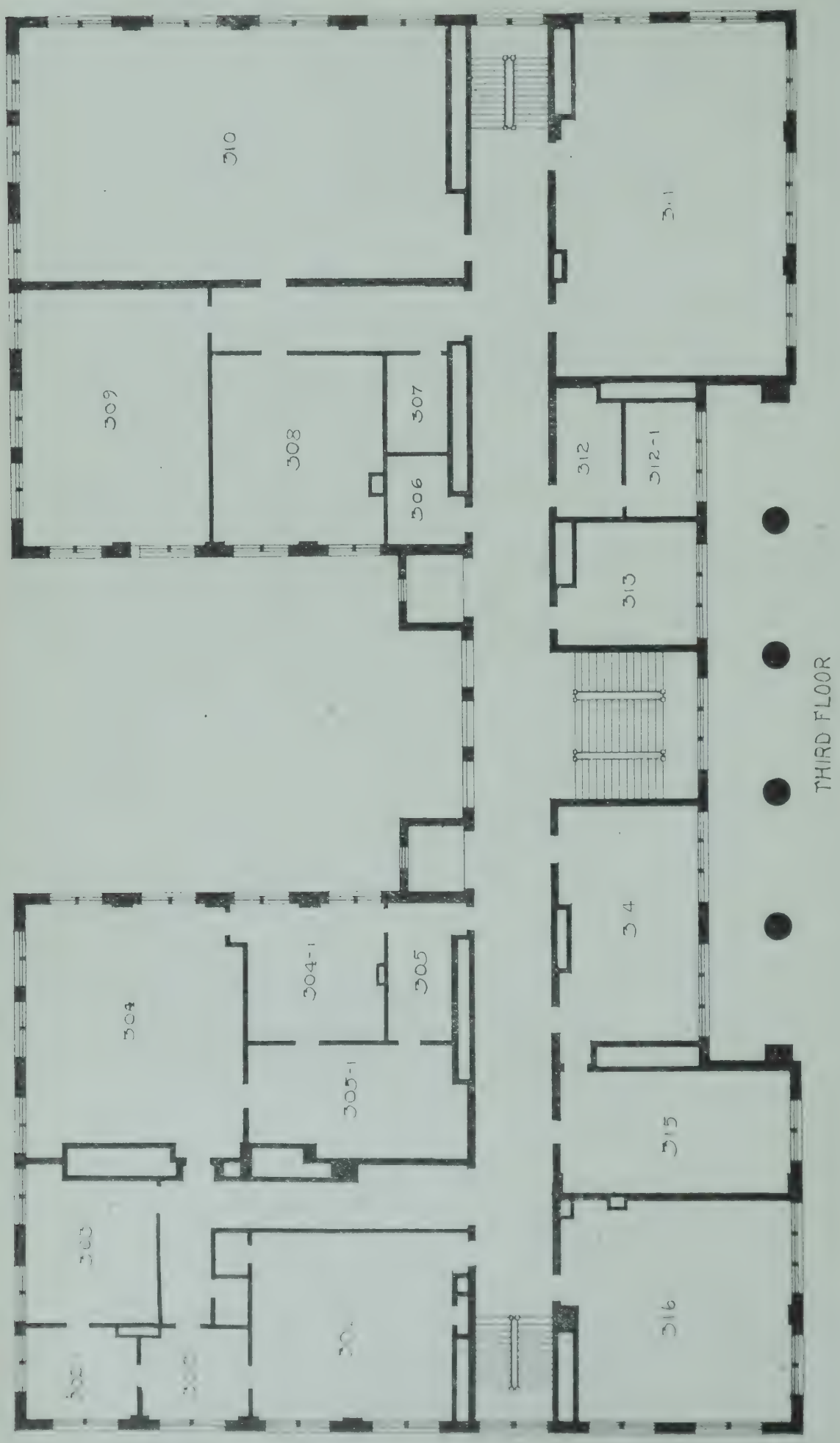
Classroom 213, 21x31 ft., is seated with forty-eight removable chairs. This room was designed as a part of the farm crops group. Room 214, 16x30 ft., was designed for advanced laboratory or classroom use but is at present being occupied by the crops breeder.

Room 215, 13x14 ft., is the outer or assistant's office in farm crops, while 215-1, 13x15 ft., is the private office of the head of the department. Room 215-2, 14x19 ft., was designed to be used either for an assistant's office or private laboratory.

THIRD FLOOR.

The entire northeast wing of the third floor including rooms 300 to 305 comprizes the laboratories of the Chemical Division of the Experiment Station. For description see Chemist's report.

Rooms 306 and 307 are special purpose and germinating rooms accessory to the crops laboratories. Room 308, 22x25 ft., is a seed and stock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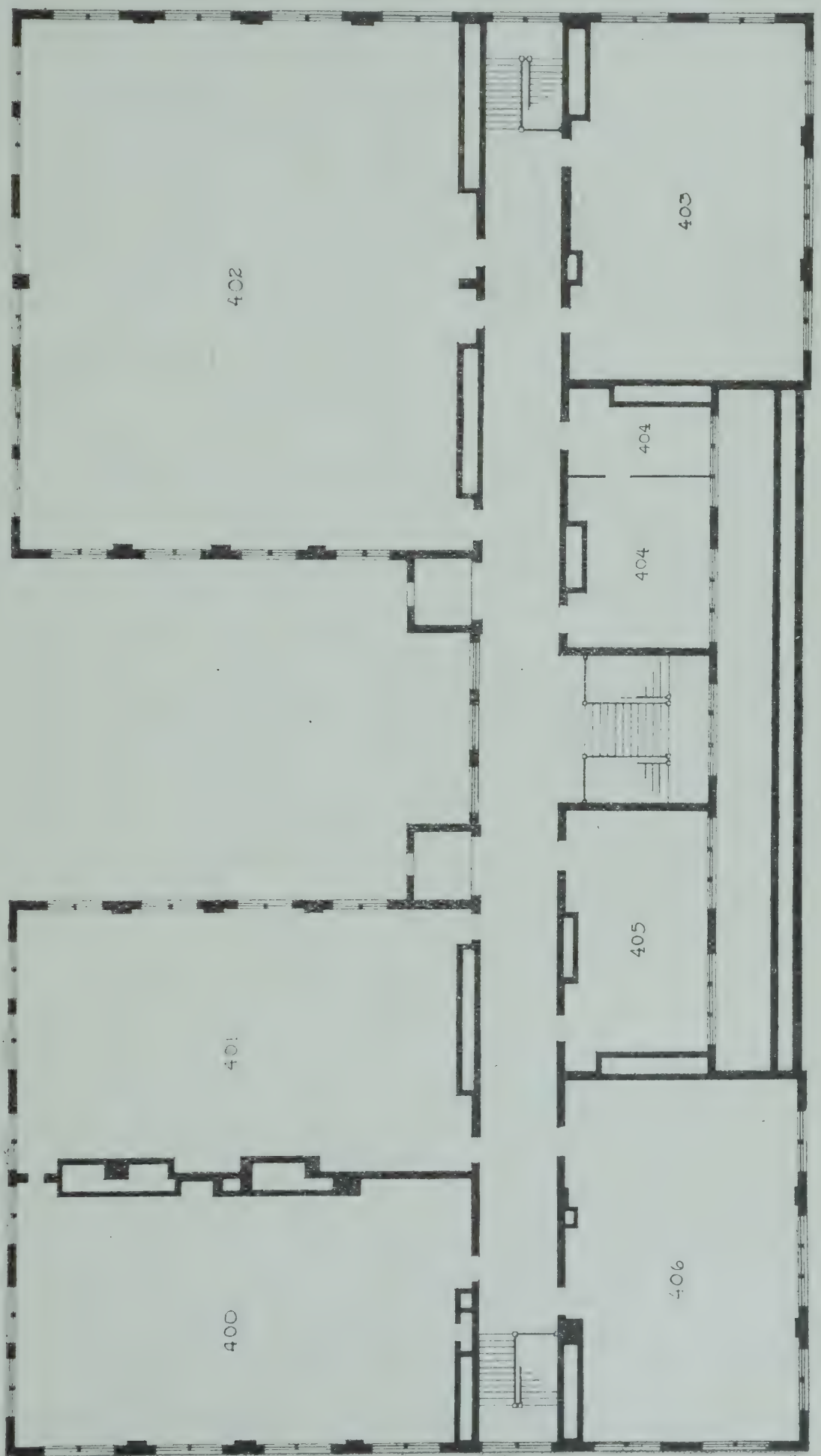
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FOURTH FLOOR

room for the storage of laboratory supplies. Room 309, 25x34, is fitted for advanced student laboratory practice in crops as well as for experimental work in the same. The crops laboratory 310, 34x56 ft., is fitted with desks to accommodate seventy-two students at one sitting. Room 311, 30x46 ft., is used as space supplementary to the crops laboratories. It can be fitted with 115 removable seats or these can be replaced by temporary laboratory tables as the occasion may demand in case of short courses, etc.

Rooms 312 and 312-1 together 15x21 ft., are being occupied temporarily by the editorial staff of the Holcad. Room 313, 16x21 ft., is an office occupied by the Associate Professor of History and Economics. Room 314, 21x31, contains forty-two permanent seats and is now being used by the department of History and Economics. The same is true of 316, 29x30 ft., with seventy seats. Room 315, 16x30 ft., is used for special classroom purposes.

FOURTH FLOOR.

The fourth floor is made up of large rooms well lighted from the walls and skylights, furnishing as attractive and useful space as there is in the building.

Room 400, 34x57 ft. has been designated the agricultural museum for the display of collections of an educational character especially pertaining to the evolution of American agriculture. Room 401, also 34x57 ft., is being used as a laboratory and storage place for the thousands of individual plants and packages of seeds of the Crops Breeder.

Room 402, 57x69 ft., covering the entire southeast wing is an assembly room for public meetings, student mass meetings, and entertainments. It has three hundred sixty seats but could accommodate about two hundred more. Room 403, 30x47 ft., is suitable for either class room or laboratory purposes and the same is true of 406, which is similar in all particulars. Room 404 furnishes toilet facilities and 404-1 is being used for storage purposes. Room 405, 21x31 ft., is being occupied by the Alpha Zeta fraternity, an organization dependent on honor attainments in agriculture for membership.

EXTENSION WORK.

During the year considerable effort has been put forth to develop extension work along agricultural lines. A description of the work in Horticulture is given in connection with the report of the Horticulturist. Some progress has been made in Soils and Crops and very gratifying results have been procured in connection with the organization of live stock breeders' associations.

A brief statement was made in the last annual report relative to the organization of cooperative live stock breeders' associations. This work has been continued by Mr. W. F. Raven throughout parts of the year and is not only meeting with success but is proving a great stimulus to live stock improvement in the state. The following is a brief statement from Mr. Raven. It is intended to give a more complete report soon in bulletin form.

The following report is submitted by W. F. Raven, Live Stock Field Agent.

Since my appointment I have visited 1,707 farms and talked with the farmers in regard to breeding their cattle to pure-bred sires. With the exception of three men, all have expressed themselves in favor of the work. Those that were unable to get or use pure-bred sires have regretted their inability to profit by them. The farmers visited owned 10,732 cows, of which number 441 were registered cows. Of the 1,707 farmers visited 197 were using pure-bred sires in their herds. Twenty-seven breeders' associations have been organized, viz.: Jersey 7, Guernsey 8, Holstein 7, Durham 2, Berkshire 2 and general 1. These associations are located in the following counties, viz.: Alpena, Berrien, Cass, Gratiot, Genesee, Grand Traverse, Hillsdale, Jackson, Kent, Kalamazoo, Lenawee, Montcalm, Missaukee, Newaygo, Oceana, Ottawa, Presque Isle, Wayne, Ionia and Van Buren. More than one-half of my time has been spent among farmers where no associations have been organized. The chief reason for failure to organize them into associations was their inability to agree as to which breed of cattle they preferred.

I have reason to believe that a large number of pure-bred sires have been bought and used since my visit to those places where no organization was effected.

Nine associations are likely to be organized at the following places viz.: Barryton, Cadillac, Coleman, Long Rapids, Midland, Auburn, Trenton, Owosso and Ossineke.

Several members of these associations have purchased one or more pure-bred females of the same breed as the sires of the associations to which they belong thus laying the foundation for pure-bred herds.

All of the associations, with two exceptions, are doing good work. These two, through some misunderstanding, have not succeeded very well but with better understanding of the work will improve.

AGRICULTURAL SURVEY.

During part of July, August and part of September, 1909, agricultural surveys were made of portions of Presque Isle and Roscommon counties. The primary object was to secure information relative to the agricultural possibilities of these portions of the state, in the hope that the College, through its extension forces, might be able to direct the development of the agricultural possibilities through cooperation with the land owner and prospective settler. The information procured included notes on the character of the soil, soil samples, timbered land, cut over land, location of streams, lakes and swamps and the area of the latter. Information was procured relative to crops which have been attempted and the results, and the same is true of horticultural productions.

While the work this season was more or less of a try-out, the experience and information of those in charge would seem to indicate that the work should be properly organized and financed so as to make more rapid progress. There is a constant demand for information of this character, which, if once procured, would place the College in a position to thwart the efforts of the unscrupulous land dealer and direct wisely as to possibilities of those portions of the upper part of the Lower Peninsula which must needs be handled in special ways peculiar to their

conditions. The following is a brief statement of the work of Mr. Raven, in charge.

I herewith submit the following report of the soil survey taken in Presque Isle county by Mr. A. R. Potts, Jesse Morrill as land looker, and myself.

Beginning on Section 1, Twp. 34, North, Range 2 East, we took samples of both surface and subsoil from every quarter section in the four townships in the southwest corner of Presque Isle county; namely: Twps. 34 north, Range 2 east; 34 north, Range 3 east; 33 north, Range 2 east; 33 north, Range 3 east.

Wherever there was forty or more acres of cedar, tamarack or other swamp lands on a section, we took samples of the soil of the swamps. The samples of soil were put in canvas sacks and shipped to the Michigan Agricultural College. The samples were numbered from one to three hundred sixty-five.

Township 34 north, Range 2 east, is a first-class agricultural section with a good, productive, limestone soil which produces good crops of wheat, oats, peas, barley, beans, potatoes, alfalfa, grasses, alsike clovers and timothy. It is a good cattle or dairy section well watered with numerous small streams, and Rainy and Black rivers. There are several sections of standing timber of maple, beech, basswood, hemlock, elm, cedar and tamarack. Not over one-eighth of this township is under cultivation. The thriving village of Onaway is in this township with its mills, and its population which consumes all the products of the adjoining farms and makes the demand greater than the supply. Wherever this land is cleared and well tilled it is very productive. The surface is quite rolling in some portions of the township, but very little is too steep for cultivation. I also submit notes of each section in a note book, and maps of each section showing where all clearings, swamps, cut-over lands and standing timber are located.

Township 34 north, Range 3 east, is a continuance of the same variety of soils and timber except the north east corner of the township on sections 1, 2, 11, 12, and 13. Most of these sections are jack pine and cut-over pine land. The soil is sand of poor quality on the pine lands. The village of Millersburg is in this township, of which not one-tenth is under cultivation.

Township 33 north, Range 2 east. The north half of this section is a good clay and clay loam soil, most of which is covered with forests of maple, beech, hemlock, elm and basswood. In the swamps are cedar and tamarack. The south half of the township is open plains, cut-over pine lands and jack pine. Most of the plains are good clover lands. In several places two or three acres had been cleared, fenced and sown to clover, and in every instance there was a good stand. In this township are three sheep ranches. The few settlers seem to produce good crops of peas, barley, oats, clover, timothy and potatoes. But little corn is planted. The soil on the plains and cut over pine lands is sand of a fair quality and where the forest fires have not burned it too severely, it is fairly productive. The jack pine land soil is of a very poor quality of sand.

Township 33 north, Range 3 east. A little over one-half of this township is clay and clay loam soil located in the north portion and the south west portion. There are not many settlers. The west and middle por-

tion is cut over pine land broken with high, steep hills, especially on sections 12, 13, 14, 23, 24, and the east half of 22. The soil on the cut over pine lands affords excellent pasture crops of clover, timothy and June grass wherever it escaped the forest fires. The jack pine is on sections 19, 20, 30, 29, 31 and 32,with a sandy soil and subsoil of sand of very poor quality.

Township 24 north, Range 2 west, is in Roscommon county. This survey was made by Mr. Timothy Kyle as land looker and myself. Samples of soil were taken from every quarter section, and where forty or more acres of marsh were found on one section, samples were taken of the marsh land as well. The samples were put in canvas sacks and shipped to the Michigan Agricultural College. The sacks were labeled and numbered both with a serial number and the section of land from which they were taken, beginning with serial number 366 and ending with number 454. This township is a poor one for farming, about 90% of it being jack pine plains or tamarack and cedar swamp and the other 10% cut over pine lands. There were more abandoned farms in this township than I saw in Presque Isle or Alpena counties. The soil on the jack pine plains is a loose sand. On the cut over pine lands the soil is a sand with a quick sand subsoil. This is especially true on sections 12 and 13. A portion of 12 and 14 is the best land in the township.

The following is a report of the lands available for agricultural purposes and lying four to six miles each side of the Ann Arbor Railroad from Lake George in Clare county to Thompsonville in Benzie county.

Beginning at Lake George, north and east the soil is sandy loam with a clay or clay loam subsoil. These lands are cut over pine lands with a thrifty second growth of white, black and red oak, and would make excellent sheep pasture. There are a few open marshes, apparently good pasture lands which, when drained, would be good grass lands. There are a few settlers here but no farmers. When a field is cleared, except the pine stumps, in most cases it is cropped continuously. Most of the settlers will work at almost anything to get a living except clearing more land. This seems to be a productive soil when well cared for. Where clover has been sown, good seedings are found. The crops grown are potatoes, rye, peas, oats, corn, clover and timothy.

West and north of Lake George the lands are slightly rolling with a soil of sand and sand loam and subsoil of clay, clay loam and gravel. This is good land for sheep farming. There are two sheep ranches here, with a few sheep, on which good clover, carrots, corn and potatoes were growing.

Mr. C. A. Gilmore, on the banks of Windover Lake, three and a half miles west and north of Lake George, has a fine ranch with sheep and cattle of good quality and was getting buildings ready for forty-five to fifty dairy cows. Of the 80,000 acres of desirable agricultural lands around Lake George, less than one-tenth is under cultivation.

North and west from Clarence is a good agricultural section with soils of clay, clay loam, sandy loam and sand, with a clay or clay loam subsoil. There is a small settlement of German farmers here making good progress in clearing and tilling their lands. This is a good dairy country and is also suitable for grazing with beef cattle and sheep. The farmers have but few cattle and those are of poor quality. They are be-

ginning dairying in a very crude way as their means will allow and seem very hopeful of having better stock in the future. But a small portion of the available lands around Clarence is cultivated.

North and west of Temple along the Muskegon river for two miles or more on each side of the river is a poor, worthless tract of land for agricultural purposes. The soil is a loose sand with sand subsoil covered with jack pine and scrub oak. In going six miles north and west along the river I found no settlers although there were several abandoned homes. North and east on the cut over pine lands the soil is of better quality, sandy loam with clay and clay loam subsoil from eighteen to thirty-six inches below the surface. I found just one farmer, C. Baluss, with good farm buildings, good cattle, sheep, hogs and horses in good condition and barns filled with hay and grain. He said he had farmed in Washtenaw county for twenty years and could produce as large crops on his farm as in Washtenaw county and produce them at less cost. His crops were corn, potatoes, rye, buckwheat, clover, wheat and timothy. On the north west side of Muskegon river about two and a half miles from the river are a few settlers on homestead lands who work in the mills at Temple and elsewhere to earn a living. About three miles west from Temple and south, is a tract comprising several sections of first class lands of clay and clay loam soils, just rolling enough for good drainage. Here are several good farms, the largest, owned by N. Church and Son, of Ithaca, Michigan, has good buildings and is operated as a sheep ranch with fair stock. There are several sheep ranches in this section. Just south and west of Temple is jack pine and cut over land of a very poor quality consisting of a loose white sand with gravel subsoil. The few settlers had only been there a year and all said they had been fooled on the soil and were ready to move on.

The soil in the immediate vicinity of Pennock is loose sand with sand subsoil, worthless for profitable agriculture. The few settlers are trying to grow potatoes, peas, corn and garden truck, without much success. West of Pennock is a better soil of sandy loam with clay subsoil, where a few settlers are just beginning to clear the land and a few others have been located three or more years. The latter are growing good crops of potatoes, peas and timothy, but have very few cattle. This is a good sheep or cattle section and the great need is more live stock, especially sheep to help clear the land of brush and briers.

Around Marion the soil is clay and clay loam with clay subsoil. This is a very prosperous community with good farm homes, good live stock and well tilled productive farms. The crops are wheat, oats, corn, potatoes, rye, beans, clover and timothy. West four miles and south two miles, are large tracts of good soil with no settlers. These lands are rolling, but can all be cultivated, have few marshes and swamps and these but small ones. East and north of Marion are good farming lands with surface less rolling than those west of Marion. Here dairying is carried on quite extensively with a fair grade of cows and a few herds of pure breds. There are several large sheep ranches near Marion, the largest and best of which is owned by Chas. Shore of Evart. In and around Marion are very productive soils settled by an intelligent class of farmers who are making good.

West and south and northwest of McBain, for five or more miles, the

soil is clay and clay loam with a few cedar and tamarack swamps, uplands covered with cobble stones and surface badly broken with steep hillsides. This land is all settled with thrifty Hollanders with good farms, buildings and fences, and fair live stock. Sheep are little raised in this section, dairying and beef raising being the live stock industries. Dairying is quite extensive west of McBain, the creamery at Lucas getting and making up most of their product. The crop of potatoes in 1909 was from 150 to 350 bushels per acre and of good quality. The other crops are corn, wheat, rye, clover and timothy.

East three miles, north and south, the soil is a good quality of sand loam with surface nearly level. There is quite an area of low land along a stream which has been cut over for hay. Less live stock is raised on the east side of McBain than on the west, and the farmers grow more grain and potatoes. These would prove good grazing lands for beef cattle. The farms are new and in good condition with good farm buildings.

South of Lucas is a continuance of the high, rolling, stony clay and clay loam soils west of McBain. This section is well settled with Hollanders who have good farm buildings and good, thrifty, productive farms raising crops of potatoes, wheat, oats, rye, corn, clover and timothy. All through this section are small, thrifty apple orchards. Dairying is carried on quite extensively with fair dairy herds. This would make a good sheep country and there are already a few flocks of good sheep. East and north of Lucas the soil is sand loam with clay subsoil and nearly level surface. The crops are potatoes, wheat, oats, corn, rye, clover and timothy. There are a few herds of good dairy cattle here. More cattle are kept in the vicinity of Lucas than in any of the settlements between Lake George and Lucas, and the farmers are intending to increase their stock of dairy cattle. There is a cooperative creamery located at Lucas which is doing a good business. West of Lucas begins the cut over pine lands of the Cadillac region. Around Park Lake the soil is sand and the surface is badly broken with steep hills and marshes.

The soil north and south east and west of Cadillac is sandy cut over pine land. The Cadillac Turpentine Company is removing the pine stumps for the purpose of making turpentine. After the stumps are pulled and removed this soil, with good care, may make fair agricultural lands. This tract extends to Bunyea's siding where the timber changes to maple, beech, hemlock and bass wood, but the soil remains about the same, sand with an occasional place where red clay crops out. This is a new country but sparsely settled and most of the settlers work in the woods or mills. Little attempt is made at farming. Most of the soil is light sand and sand loam producing good crops of potatoes and corn. There are a few cattle but no sheep.

East, north and south of Boon is good agricultural land of sandy loam and sand soils. The crops raised here are potatoes, corn, wheat, rye, clover and timothy. These lands afford excellent pasture for sheep and cattle. The cleared farms are under good cultivation with quite a number of cattle and hogs, but few sheep. Not over one-third of the land in the vicinity of Boon is under cultivation. A large portion of the lands west of Boon have a high rolling surface with very steep hillsides better adapted to sheep farming than crops. These lands furnish excel-

lent pasture where the forest fires have been kept off the cut over lands.

South and north of Harrietta the surface of the land is broken with very steep hills. The few settlers on these lands raise potatoes, corn, rye, clover and timothy. The soil is a sandy loam. It is my opinion that these steep hillsides cannot be farmed with profit but are well adapted to sheep as they afford fine pasture. All along the timber roads the clover, timothy and June grass grows luxuriantly. If these lands when burned over could be sown to alsike, June clover and timothy, they would produce good seedings; and better yet, if the forest fires were kept out of these lands, they would reforest themselves with maple, beech, basswood, hemlock and birch, covering the entire surface. Wherever the fires have been kept out this is demonstrated.

The vicinity of Yuma has a sandy loam soil and but few settlers. There are thousands of acres here for the settlers who want lands on the cut over hardwood sections that would make good farms well adapted to cattle or sheep farming, dairying, or general farming. The settlers here grow potatoes, a few patches of corn, rye and timothy hay and depend on logging for a living. One and a half miles west of Yuma is a logging camp. The surface of the cleared lands and most of the cut over lands, except a narrow valley, is high and rolling, broken with quite steep hills and would make excellent land for sheep ranches.

East and south and east and north of Mesick the land is well settled. The soil is sandy loam of very good quality well adapted for dairying and general farming. Potatoes form the chief crop, supplemented by small fields of wheat, rye and buckwheat and some clover, but more timothy. The surface is broken with marshes and hills not so steep but that most of them can be tilled. There are a few good apple orchards. The farmers of this vicinity who come from Ohio and Indiana, are clearing and breaking their land and keeping as large a number of a good grade of live stock as they have forage for wintering.

Bagnell has but few settlers, and these are good farmers. The soil is a sandy loam with surface broken by hills, some of them very steep, and a few marshes. There are but few cattle, sheep or hogs and the crops grown are potatoes, buckwheat, wheat, corn, clover and timothy.

The lands around Pomona are the best for general farming so far, west of Cadillac. The soil is sandy loam of excellent quality with clay subsoil. The crops are wheat, buckwheat, potatoes, corn and timothy hay. I saw a few apple orchards that looked thrifty and, in most cases, well cared for. There were more acres of good winter wheat around Pomona than between Pomona and McBain. The yield in 1909 was from 18 to 38 bushels per acre. Potatoes yielded from 75 to 300 bushels per acre. There are good farms and farmers in the vicinity of Pomona with good substantial farm buildings. Not much live stock is kept and I believe that more could be kept with profit. The farmers there do not agree with me and think that with wheat, buckwheat and timothy hay, and using clover to plow under for fertilizer, they get better returns.

The soil in the vicinity of Copemish is a sandy loam of good quality with clay subsoil which often crops out to the surface. The crops are wheat, potatoes, buckwheat, beans, oats, corn, clover and timothy. This is a first class country for general farming or dairying and more live stock could be kept with profit. The live stock is mostly beef cattle,

sheep and hogs. More hogs are kept around Copemish than in all the country from Lake George to Copemish. The farms are in first class condition with good substantial farm buildings. There are quite a number of small apple orchards which are well cared for. The high lands around Copemish would make good apple lands.

The soil around Thompsonville is sand with a clay loam subsoil from twelve to eighteen inches below the surface. The soil is more sandy than at Copemish but seems to be very productive. The crops are potatoes, wheat, rye and buckwheat with small fields of corn, beans and hay. There is a large, well-kept orchard owned by Samuel Willis, close to the village. He stated that over 10,000 apple and peach trees would be set in the spring of 1910 in the vicinity of Thompsonville.

The country from Lake George to Lucas four miles each side of the Ann Arbor Railroad, except three or four miles each side of the Muskegon river, is fertile soil adapted to sheep, beef, dairy or general farming. So far as I could learn, every time a man gets a piece of this land and sticks to his work and business (his work clearing land and his business farming) he makes good.

From Lucas west and north to west of Otsego lake to Bunyea's siding is cut over pine land. The soil is sand of poor quality and some of the surface is badly broken with steep hills and marshes. From west of Otsego lake the soil is more productive and of better quality, in some places badly broken with steep hills, especially at Harrietta. From Mesick to Copemish the surface is more level and the soil more productive. Just east and south of Thompsonville comes the cut over pine lands. This soil is sand but of a much better quality than at Cadillac and it seems more productive. From Bunyea's siding to just east and south of Thompsonville are hard wood lands.

Respectfully submitted,

R. S. SHAW,
Dean of Agriculture.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF SOILS.

President J. L. Snyder:

Dear Sir: During the year just closing this department has given instruction to four hundred and sixty-five students, averaging one hundred and fifty-five students per term, and comprising thirteen classes.

The change of quarters from the old building to the new, together with the better and long needed equipment, has made it possible to do much more for the students since the change than at any previous time.

We now have a fine, large, well lighted, well ventilated, lecture room 36½ feet by 50 feet. It is now seated for 144 students but its capacity can be increased somewhat beyond this number. Two smaller lecture rooms, each with a seating capacity for 48 students, are available for the use of this department whenever needed. We have two general labora-

tories, each 31½ feet by 47½ feet, and each is fully equipped with desk room to accommodate 48 students, 96 in all. Connected with these laboratories we have an apparatus room and a stock room, the latter of which is already equipped with drying oven and furnace, and by the beginning of the school year will have other apparatus in place for use in carrying on the work of student instruction. A private laboratory 20 feet by 29½ feet can be used part of the time if necessary for student work. Present indications are that it is only a matter of a short time when these splendid quarters and equipment will be taxed to their capacity.

The improved quarters and equipment are leading to expansion and modification of our courses of study. We are looking forward with pleasurable anticipations to the year before us.

There has been a large and increasing demand for help in college extension work in the way of talks before juvenile clubs, farmers' meetings, etc. There has been a growing demand for work in boys' corn meetings. It has been impossible for this department to meet all these demands. With the growing work of the department it has been necessary also to lessen the time which we have been able to give to the farmers' institute work.

Mr. C. H. Spurway, a graduate of the class of 1909, has rendered very efficient service as instructor in the department during the year.

Respectfully submitted,

JAS. A. JEFFERY,
Professor of Soils.

East Lansing, Michigan, June 30, 1910.

REPORT OF THE DEPARTMENT OF DAIRY HUSBANDRY.

President J. L. Snyder:

Dear Sir: In making the report of the Department of Dairy Husbandry for the year ending June 30, 1910, we wish first to express our appreciation for the very ample provision made for all live stock teaching in the new Agricultural building, the quarters which we have occupied since January 1, 1910. A grade of work can be done with the present equipment which was not possible under the former existing conditions. When the dairy manufactures division is as adequately and conveniently housed, a still further advance in this very important branch of Michigan's agriculture may confidently be expected.

During the past year, the instructional work in dairy manufactures has been immediately in charge of Mr. W. B. Liverance, who was assisted during the short courses by Mr. Simon Hagadorn, Mr. Claude A. Grove, Mr. J. C. Gilbert, and Mr. Charles H. Dear. Twenty Seniors and Specials took the work in creamery butter making during the fall term. During the spring term, seventy Sophomores were instructed in farm dairying. Forty-one creamery men enrolled for the short course in butter making; four for the course in creamery management; ten for the cheese course; and forty-five for the course in farm dairying.

The work in dairy live stock and dairy cattle judging has as heretofore been given in conjunction with the other live stock teaching.

The inauguration of the one week's course proved very attractive to the dairy farmer, sixty-five men from twenty-seven different counties were enrolled, staying from Monday noon until Saturday noon. The earnestness and enthusiasm of these men of mature years, coupled with their years of practical experience, rendered the course even more profitable than had been anticipated. A detailed program is appended:

Dairy Week—February 28-March 5, 1910.

8:00 to 9:00	Animal Breeding.....A. C. Anderson
9:00 to 10:00	Feeding Dairy Cattle.....Dean R. S. Shaw
10:00 to 12:00	Sec. 1—Study of Dairy Cows.....A. C. Anderson
	Sec. 2—Babcock Testing and Separators. W. B. Liverance
1:00 to 3:00	Sec. 1—Babcock Testing and Separators. W. B. Liverance
	Sec. 2—Study of Dairy Cows.....A. C. Anderson
3:00 to 4:00	Tuberculosis.....Dr. C. E. Marshall Dr. W. Giltner.
4:00 to 5:00	Dairy Records and Equipment.....A. C. Anderson

We are pleased to report that the past year has been a profitable one for the dairy herds. They have suffered less detriment from abortion than formerly. The tuberculin test administered to all the animals old and young, resulted in only two reactions; both animals were slaughtered and disclosed the disease in incipient form only.

The milk product from the herd during the past year has been exceptionally good. The Jerseys and Guernseys are under monthly inspection for semi-official yearly records in the Advanced Registry. During the winter vacation the Jersey cow, College Queen, 195623, was given a seven day test for Register of Merit. She gave 17 pounds, 11 ounces of butter fat from 322 pounds, 1.6 ounces of milk, at 5 years of age. An inspection of Jersey records made during the last year shows this to be the second best seven day record made by any Jersey cow during that time. All the Holstein cows are already entered in the Advanced Registry on seven day records. Among the Holstein records made during the year, two are especially worthy of mention. Bonheur Lassie 2d, 113068, gave 470 pounds of milk containing 16.498 pounds fat in 7 days as a senior 2 year old, while College Houwtje De Kol, 103909, gave 560 pounds of milk containing 20.205 pounds fat in 7 days as a senior 3 year old.

A comparison of the 7 day records of Belle Sarcastic, Rosa Bonheur 5th, and Houwtje D. with the yields of College Houwtje De Kol show that this heifer has equaled the butter fat production of those mature cows, before she has reached the age of four years. Records of this size do not, however, elicit the comment that they formerly did. The development of the capacity of the dairy cow has been so rapid and so general in the past few years that one cannot safely foretell the limit of possible production.

A report of a feeding trial of pea bran for milch cows which has not been printed elsewhere is appended to and made a part of this report.

The pea bran used is the by product remaining from the manufacture of split peas, and is composed of the hulls or outer coatings of the peas and such small particles of the meat of the peas as are chipped off during the splitting process. The first step in the manufacturing process is to kiln dry the peas, hence in feeding this product the manufacturers recommend that the bran be soaked a few hours before feeding. Their suggestion in this respect was complied with. The pea bran was tried out against the grain rations which we were feeding the dairy herd. The herd ration was:

Wheat bran	3 parts
Cotton Seed Meal	1 part
Linseed Meal	1 part
Gluten Feed	1 part

The cost of this mixture ranges between $27.00 and $29.00 per ton. The pea meal was quoted at $25.00 per ton, consequently in feeding, one-eighth more of the pea meal was used than was being fed of the herd mixture; thus the amounts of grain fed before beginning the trial and during the trial, while not of equal weight, were approximately of equal value.

The feeding was begun May 7th, and a portion of the grain ration of each cow was withdrawn and its place filled with some of the soaked pea meal, until on May 10th all the animals were receiving no other grain than pea meal. The feeding period lasted seven days, at the expiration of which time the herd mixture was again fed. In addition to the grain fed, each cow received between 28 and 32 pounds of corn silage and about 8 pounds of mixed hay per day.

As a basis for comparing the yields of each animal while consuming the pea meal with her yields while on the regular grain ration, her product for 5½ days previous to feeding the pea meal is taken together with her product for 5½ days after the regular ration is again fed.

These yields are set forth in columns one and four of the following table, while in column five the average for these two periods is given as the best basis for comparison.

Below will be found tables setting forth the yields of the several cows during the several periods.

Table 1 shows the yields of the five cows receiving the pea meal, and Table 2, the yield of the five cows receiving the regular ration, only.

The yield per day of five cows for 5½ days previous to receiving pea meal are in column 1; yields per day for three days while getting on feed are in column 2; yields per day for seven days while consuming pea meal only are in column 3; yields per day for 5½ days after returning to original ration are in column 4; average for columns 1 and 4 in column 5.

TABLE I.

Name of cow.	1	2	3	4	5
Houwtje Maid's Colantha	33.3	37.0	35.2	35.4	34.35
Handy Queen Jane	35.5	37.7	35.9	37.1	36.3
Bonheur Lassie	29.2	32.3	30.0	30.2	29.7
Stella Canary Mercedes	32.3	34.7	33.6	30.6	31.45
Coloma Canary	48.7	51.7	49.7	49.5	49.1
Average daily production of all	179.0	193.4	184.4	182.8	180.9

Percentage of increase of 2 over 5..... 6.9%
Percentage of increase of 3 over 5..... 1.9%
Percentage of increase of Ave. of 2 and 3 over 5.... 3.4%

Yields of check animals for the several corresponding periods covered in Table 1.

TABLE II.

Name of cow.	1	2	3	4	5
18	31.9	34.2	32.2	31.0	31.45
11x	22.1	22.3	24.0	23.0	22.55
Bonheur Lassie 2d	29.6	31.2	31.6	30.6	30.1
Houwtje De Kol	49.2	49.6	51.4	47.2	48.2
25b	26.4	27.7	26.9	26.4	26.4
Average daily production of all	159.2	165.0	166.1	158.2	158.7

Percentage of increase of 2 over 5..... 3.9%
Percentage of increase of 3 over 5..... 4.6%
Percentage of increase of Ave. of 2 and 3 over 5.. 4.4%

From a study of Table 1, it might seem that the feeding of the pea meal occasioned an increase of between three and four per cent in milk yields, but a comparison with Table 2 shows that for the same period the five check animals gave an increase of between four and five per cent.

It will be borne in mind that these cows were already receiving a liberal amount of a well balanced grain ration, and in as much as they maintained their normal milk flow on the pea meal, we may conconclude that it is a satisfactory grain for milch cows. It is a far better food for milk production than many farmers are feeding.

Respectfully submitted,

A. C. ANDERSON,
Associate Professor in Charge.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF ANIMAL HUSBANDRY.

President J. L. Snyder:

Dear Sir: The instruction work during the past year has been very heavy, making it necessary to entrust the care of the herds and flocks almost entirely to common labor, which has been found very unsatisfactory, owing to the irresponsible character of the help obtainable. With a view to remedying this condition, Mr. J. A. Waldron of this year's graduating class has been employed for the coming year, and will have charge of the sheep and beef cattle.

In Agriculture 1 b, a study of the breeds of sheep and swine, required in the fall term, Sophomore year, 107 students were enrolled. Owing to a lack of help, it was necessary to handle the entire class in one section, making it very difficult to get the maximum amount of work out of the students, or to give those really interested in live stock as thorough a course as is desirable.

In Agriculture 1 a, a study of the breeds of beef and dairy cattle, required in the fall term, Freshman year, 171 students were enrolled. The breeds of dairy cattle were given by the Dairy Husbandry Department, and of beef cattle, by the Animal Husbandry Department. This class was handled in two sections and very satisfactory work was done.

In Agriculture 1 c, stock judging, 15 Seniors were enrolled. This course is entirely practical, consisting of the judging and selection of the best individuals from a ring of five or six animals. This work was carried on with all classes and types of farm animals. In connection with this work, the class was taken to the Ionia County Fair, and through the courtesy of the officials were given passes and allowed to judge the cattle, sheep, and swine, their placings being passed upon by the instructor in charge and the reasons for the placings discussed befor the awards were made. This work proved very valuable, as the students gained much from the exhibitors as well as from the handling of both grade and purebred live stock such as is found upon the average farm throughout the state. It seems unfortunate that the class is not allowed more time away from the College for this work; only one day being allowed last fall.

The new pavilion greatly facilitated the handling of the short course classes, enabling the students to do much better work in studying and judging live stock. One hundred twenty-four first year short course men were given instruction in the breeds of beef cattle, sheep and swine. This class took a keen interest in the subject and did exceptionally good work. There were 40 second year men enrolled for the stock judging work.

In addition to the above, a one week's course was offered to those interested in swine growing. Coming as it did about the middle of March, this course was not very well attended, owing, undoubtedly, to the favorable weather which permitted of spring work being done and the fact that the furrowing season was at hand and few farmers could get away from home. During this week, three hours per day were spent in

studying the various breeds and judging swine; one hour to a lecture on the diseases of swine, which was given by Doctors Marshall and Giltner of the Bacteriological Department; one hour each to lectures on the feeding and breeding of swine, which was handled by Professor Anderson; and one hour each to lectures on forage crops for swine, and equipment for handling swine.

In the herds and flocks several changes have taken place during the past year. The Shorthorn herd was added to by the purchase of four two year old heifers from Mr. H. B. Peters of Burton. A Shorthorn bull to replace the one which had been used for two years was purchased of Mr. W. G. Anderson of St. Johns, Michigan. The herd now numbers 31 head, consisting of one bull, 11 cows, 8 yearling heifers, 7 calves, and 4 steers.

The Aberdeen Angus herd was increased during the past year by the purchase of two heifers from Mr. James Bowman of Guelph, Ontario, and now contains 1 bull, 4 cows, 2 heifer calves, and 3 steer calves.

The Hereford herd has been added to by the purchase of two cows with heifer calves by their sides from Mr. Merritt Chandler of Onaway, and now consists of 3 cows, 3 heifer calves, 4 steers, and 1 bull.

Owing to the increasing popularity of Red Polls, and the demand for a dual purpose breed of cattle, it has been deemed advisable to establish a herd of Red Polls. A cow, yearling heifer, and bull calf have been purchased of Mr. E. W. English of Clarksville, Michigan, and two heifer calves from Mr. E. S. Carr of Homer, Michigan.

The College flock now numbers but 189 head, consisting of 35 Shropshires, 29 Hampshires, 30 Oxfords, 19 Dorsets, 11 Southdowns, 14 Cotswolds, 33 Rambouillets, and 18 Grades. The flock has been very materially reduced by the sale of the grade flock; this was made necessary by the crowded condition of the farm, and rapid increase of the purebred flock. In the future the purebred ewe flocks will be used for experimental feeding work. An imported Hampshire ram has been purchased of Mr. M. C. Ring of Neillsville, Wisconsin, and a Shropshire from Mr. Harry Potter of Davison, Michigan.

Since August 1, 1909, the swine herd has been directly in charge of Mr. John Bowditch, Jr., who has also very satisfactorily handled the class work along this line. The herd now consists of 136 head, representing 6 different breeds. The herd has been strengthened by the purchase of a Berkshire and Poland China boar, and 3 Chester White sows.

The plan with the herds and flocks is not to keep a large number of individuals, but rather to practice very careful selection, thus increasing the quality of our stock, rather than the numbers.

Respectfully submitted,

GEO. A. BROWN,
Instructor in Charge.

East Lansing, Michigan, July 15, 1910.

REPORT OF THE POULTRY DEPARTMENT.

President J. L. Snyder:

Dear Sir: During the past year, there has been considerable interest taken in the poultry work and the new office in the new Agricultural building as well as permission to use the building for class room work, have made possible the handling of the work with greater efficiency than heretofore.

During the fall, nine men were enrolled in Ag. 5b; in the winter, 12 men were enrolled for Ag. 5c; and in the spring, five men took the work outlined as Ag. 5d. In the winter term a special short course in poultry, consisting of eight weeks, was given and ten men took advantage of this opportunity. Mr. George Hubbard a former graduate, assisted in this work, and a very satisfactory course was given. In the spring term, a special course in poultry raising was given to Seniors as a part of their animal nutrition work. There were 21 men enrolled.

During the year, the department worked in conjunction with the other departments in giving work. In the fall term a week was spent in the study of breeds of poultry with the Sophomores. In the winter, lectures of a similar nature were given to the regular short course men, and in the spring lectures on feeding were given as a part of Ag. 3a.

Several exhibits of poultry at the county fairs were judged. In addition, considerable institute work was carried on as well as three weeks of Institute Train work.

The poultry show during the winter was a new feature. The contest was opened to the public and over 300 birds were entered by outside people, which furnished the students an excellent opportunity to study the various breeds. J. W. Mulinix of Toledo, spent four days working with the students and talking to exhibitors, making it a very practical and beneficial feature.

Exhibition coops have been purchased for show work, judging and institute train work. Two new incubators and four new brooders have been added to the equipment. The stock has been universally healthy and has been quite productive. About 1,600 little chicks have been raised to replace the old and keep the quality up to standard. It is the plan to introduce White Rocks and Rhode Island Reds into the breeding pens during the year.

It is the aim of the department to adapt the course to the student's needs and to teach him the principles of poultry raising, making the work as thorough and practical as possible.

It is the hope that the people of the state in general may be brought to the realization of the possibilities of poultry on the farm and adopt better methods for its care.

H. L. KEMPSTER,
Instructor in Charge.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF FARM MECHANICS.

July 9, 1910.

To President J. L. Snyder:

Dear Sir: The following is a report of the Farm Mechanics Department for the year ending June 30, 1910.

The general results of the year's work have been quite satisfactory, considering the somewhat overcrowded condition of the shops during the short courses and the necessary confusion arising from taking possession of the laboratories in the new Agricultural building immediately upon completion. Much of the work given has been, as heretofore, more or less experimental, and considerable time will need to be spent in adjusting the work to meet the conditions of the class room and laboratory as well as to select and arrange satisfactorily the equipment which will be needed.

The work in the Wood Shop was given as planned by my predecessor, Mr. L. J. Smith, with but few changes. The exercises are for the most part well adapted to the end in view, viz.: To familiarize the student with the carpenter tools in common use. For the short courses, the services of Mr. Frank Parker, a practical carpenter and engineering graduate of '09 at this institution, were secured as instructor, in which capacity he was very successful.

Mr. A. Watt's first year's work as instructor in Forge Shop has been very commendable. Mr. Watt has proven a capable instructor as well as an efficient worker in doing the horse shoeing and repairs for the farm with promptness and dispatch.

We appreciate the space given the Farm Mechanics Department in the new Agricultural building, which was first used during the short courses and enabled the work to be given under favorable conditions, although lack of time compelled a rather hasty temporary installation of the machinery.

In the work in Farm Mechanics 3 and 4, given to the Juniors, the usual exercises in Power Machinery were performed. Some new work was attempted with farm implements, particularly with the manipulation of the binder, calibration of the grain drill, and checking the accuracy of drop of the corn planter, with a view to familiarizing the student with the operation of the above named machines. Some field work with the draft of plows, discs, etc., would be of value to the student.

In addition we might say that the Wood Shop has been enlarged to occupy practically the entire second floor of the Farm Mechanics building and plans are under way to increase the capacity of the Forge Shop which seems to be necessitated by the increased number of students.

Respectfully submitted,
H. H. MUSSELMANN,
Instructor in Charge.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF HORTICULTURE AND LANDSCAPE GARDENING.

To the President:

The class work in this department has been given as scheduled in the catalogue, except a slight rearrangement necessitated by changing the freshman class in plant propagation from the spring to the winter term. This was done to assist the Soil Division of the Agricultural Department, as it then gave the freshmen to them in the spring term.

The changes made in the subject matter of some of the upper classes last year have been very satisfactory, and it is believed the effort to make the work of the courses more fundamental and less popular is justified, and it will be continued.

It has been possible to do a little more work on improving the campus and the collection of trees and shrubs has been slightly enlarged. It is hoped that this work can be carried further. A good deal of time and funds has been used in grading about new buildings and filling up the hole of the former lake at the rear of the Women's Building.

The effort to improve the gardens and orchards in appearance and objects has been continued, and it is hoped to do considerable more next year.

The extension work in horticulture is meeting with splendid success. A special effort has been made to assist farmers who have manifested a desire to apply modern methods to old apple orchards, and to advise in regard to new plantings in such matters as site, varieties, planting, pruning, and cultivation. Considerable effort has been made to demonstrate the advantages of spraying potatoes. In all of this extension work an effort has been made to interest the people of the neighborhood and this is best done by demonstrations in the orchards and field.

The short course in "Fruit Growing" was increased from two to four weeks and the attendance was larger than ever before. The success of the course was due in a large measure to the assistance of the instructors in the Botanical Department and the Soils and Farm Mechanics Divisions of the Agricultural Department, and to the members of the Chemical Division of the Experiment Station.

Several members of the department have attended a few Farmers' Institutes and a few High School Agricultural Meetings that were arranged by the Department of Agricultural Education.

An excellent spirit exists among the members of the department and this has helped to make the work of the year a success.

It is a pleasure to report that the work of Assistant Professor C. P. Halligan, Instructors Thomas Gunson and O. I. Greeg, College Field Agent in Horticulture O. K. White, and Foreman A. Davis has been thoroughly satisfactory.

Respectfully submitted,
H. J. EUSTACE,
Professor of Horticulture.

East Lansing, Mich., June 30, 1910.

REPORT OF THE DEPARTMENT OF AGRICULTURAL EDUCATION.

President J. L. Snyder:

Dear Sir: I herewith submit a report of my labors for the past year:

(1). I have taught two regular classes in pedagogics during the year eight hours per week and a special class in pedagogics of agricultural Seniors, giving a course in school management and pedagogy covering a half year's work.

(2). I have given addresses in eight farmer's institutes and eight teacher's institutes and have also visited a number of granges and farmer's clubs in the interests of our extension reading course.

(3). I have prepared a bulletin, known as Bulletin No. 4, on nature study and rural sociology for the special use of County Normal training classes and for use in the rural schools. This bulletin has been sent out to all the training classes in Michigan and, on request, to a large number of teachers.

(4). We have enrolled about the same number of individuals in the College extension reading course as were enrolled last year. We have organized reading clubs in four farmer's clubs and in twenty granges, with a total enrollment of about two hundred twenty. The books which have been presented this year are: For the women, Conn's "Bacteria, Yeasts and Molds in the Home" and "Theory and Practice of Cookery" by Williams and Fisher; for the men, Bailey's "Principles of Fruit Growing" and Robert's "Business Handbook." The outline of the work was published in pamphlet form and distributed to all the granges and farmer's clubs in the fall, and the course for the ensuing year is partially organized.

(5). I have visited about fifty High Schools during the year, giving special attention to the possibilities of introducing agriculture in the future.

(6). I have had charge of the teacher's registry for graduate students. Nearly all the students have enrolled and a number of them have secured good positions for next year. Up to the present time six of the young ladies have secured positions. I have located several of the men who expect to teach outside of the state.

AGRICULTURAL EDUCATION.

(1). During the past year we have had six High Schools giving a course in agriculture. In each case the course was presented by a graduate of this institution and the work has been satisfactorily done and so far as I can learn has given local satisfaction. In connection with the work of these High Schools, special lectures were presented from time to time by the young men in charge and by members of the College faculty. The farmers in the vicinity of the High Schools were invited in and in every case responded promptly, the attendance ranging in different schools from twenty to one hundred fifty farmers in

addition to the High School boys. Various subjects were presented. In every case we aimed to meet the desires of the farmers and presented such subjects as would meet their needs. Fruit growing, stock breeding, feeding, soils, farm crops, and veterinary operations received attention. I consider this a valuable feature of the agricultural educational work. The opportunity offered by having agriculture presented in the local High Schools for this purpose alone is without question most valuable for the locality and for the state.

(2). Four new High Schools have organized courses in agriculture for the ensuing year, Watervliet, Northville, Saline, and Union City. One other place is considering the course and may introduce it later. The young men who will have charge of these new schools are as follows: Stanley A. Martin, Watervliet; H. H. Douglass, Northville; E. L. Rodegeb, Saline; C. L. Nash, Union City. All of the High Schools which have been giving agriculture during the past year will continue the course, with the possible exception of Lawton. This matter is still under consideration. In addition to these schools, the Traverse City High School will introduce a course in horticulture and gardening, and Saginaw (E. S.) will probably have work in gardening. The city of Hart is considering the introduction of a course in horticulture and possibly agriculture. The matter is not yet settled.

From the present outlook we shall have twelve High Schools giving regular courses in agriculture by special instructors during the year of 1910-11. Several other High Schools will give elementary courses in agriculture in order to interest the young people in the project and pave the way for regular scientific work.

This, in brief, is a summary of my work for the past year.

Very respectfully,
WALTER H. FRENCH,
Professor of Agricultural Education.

East Lansing, June 30, 1910.

REPORT OF THE DEAN OF ENGINEERING.

East Lansing, Mich., July 1, 1910.

Dr. J. L. Snyder, President, Michigan Agricultural College.

Dear Sir: I have the honor to present the report of the Dean of Engineering for the fiscal year ending June 30, 1910.

ORGANIZATION.

Since the last report the work in mathematics hitherto coupled with civil engineering has been constituted a separate college department with Prof. Warren Babcock as its head, and the Departments of Civil Engineering, Drawing and Design, Electrical Engineering, and Mechanical Engineering, have been constituted the Division of Engineering, which is one of the four coördinate divisions of the College, the others

being Agriculture and Forestry, Home Economics, and Science and Letters.

With this change there was established the Faculty of the Division of Engineering, consisting of those members of the teaching forces of the several departments of the division whose major work is with engineering students, and the professor of mathematics, the professor and one assistant professor of chemistry.

The complete *personnel* of the Faculty of the Division of Engineering at the close of the fiscal year is as follows:

G. W. Bissell, Dean of Engineering and Professor of Mechanical Engineering.
H. K. Vedder, Professor of Civil Engineering.
A. R. Sawyer, Professor of Electrical Engineering.
V. T. Wilson, Professor of Drawing and Design.
W. Babcock, Professor of Mathematics.
F. S. Kedzie, Professor of Chemistry.
L. L. Appleyard, Assistant Professor of Mechanical Engineering.
J. A. Polson, Assistant Professor of Mechanical Engineering.
C. Newman, Assistant Professor of Drawing.
W. L. Lodge, Assistant Professor of Physics.
A. S. Rosing, Assistant Professor of Civil Engineering.
A. J. Clark, Assistant Professor of Chemistry.
*W. B. Wendt, Instructor in Civil Engineering.
W. E. Laycock, Instructor in Physics.
L. S. Fuller, Instructor in Civil Engineering.
H. E. Marsh, Instructor in Physics.
C. C. Wilcox, Instructor in Mechanical Engineering.
P. N. Ford, Instructor in Drawing.
C. C. Cobb, Instructor in Drawing.
G. A. Kelsall, Instructor in Electrical Engineering.
J. T. Buser, Instructor in Civil Engineering.
O. W. Fairbanks, Instructor in Civil Engineering.
W. H. Hartman, Instructor in Mechanical Engineering.
E. C. Baker, Instructor in Mechanical Engineering.
A. P. Krentel, Instructor in Mechanical Engineering.
W. R. Holmes, Instructor in Mechanical Engineering.
A. Smith, Instructor in Mechanical Engineering.
C. L. Brackett, Instructor in Mechanical Engineering.
In addition,
E. Roller, Instructor in Physics.
Miss C. Holt, Instructor in Drawing.
Miss I. Snelgrove, Instructor in Drawing.

Are attached to the respective departments for instruction in classes of non-engineering students.

* To be assistant professor in 1910-11.

Student Enrollment.

The enrollment in the engineering course for the past year is as follows:

Seniors	48
Juniors	74
Sophmores	120
Freshmen	172
Sub-freshmen	81
Special	5
Total	500
Graduated, June, 1910	40

Professional service degrees were granted to:
A. C. Dodge, Civil Engineer, (C. E.)
J. P. Haftenkamp, Civil Engineer, (C. E.)
W. F. Uhl, Civil Engineer, (C. E.)

For the first time a group photograph of the senior engineers was taken at near the close of the year. This will be framed for hanging in Engineering Hall and will be the nucleus of a portrait record of our graduates.

The Course of Study.

Experience with the new course of study gives reason for the belief that it is somewhat too severe in the amount of work required of students and that quality suffers thereby, although the course is more satisfactory in many ways than that which it superseded. Attention is being given to the subject of modifying the course in severity.

Alumni.

The completion of the twenty-fifth year of engineering at the College and the recurrence of the tri-ennial alumni reunion suggested special efforts to get in touch with the engineer alumni. In doing this, considerable interesting and valuable information concerning the location, vocation and success of the graduates was obtained and from the data secured a "Directory of Engineer Alumni" was complied, printed, and distributed to all graduates whose whereabouts were known.

From 1885 to 1910 inclusive, 406 men have graduated from the engineering course and many more have taken one or more years as shown in Table I.

TABLE I.

Statistics of attendance of engineering students.

Year.	Enrollment in engineering.		Graduates.
	Freshmen.	Total.	
1886–87			
1887–88			2
1888–89	39	93	6
1889–90	59	113	9
1890–91	64	127	6
1891–92	45	114	5
1892–93	56	120	8
1893–94	45	122	7
1894–95	36	131	6
1895–96	39	128	7
1896–97	49	120	6
1897–98	82	140	4
1898–99	83	165	6
1899–00	129	232	10
1900–01	54	241	11
1901–02	78	249	20
1902–03	100	309	26
1903–04	131	353	19
1904–05	110	395	26
1905–06	117	393	42
1906–07	113	384	45
1907–08	174	485	47
1908–09	178	498	49
1909–10	172	500	41

Table II shows the geographical distribution of our graduates.

TABLE II.

Geographical distribution of engineering graduates of the Michigan Agricultural College, compiled from information received from Jan. 1 to May 23, 1910, from 196 out of 269 graduates in the classes '88 to '07, inclusive.

Arizona	1	Michigan	67
California	4	Missouri	3
Canada	6	Montana	2
Colorado	2	New Jersey	1
Connecticut	2	New Mexico	1
District of Columbia	8	New York	12
Georgia	1	Ohio	16
Idaho	2	Oregon	2
Illinois	34	Pennsylvania	7
Indiana	3	Phillipine Islands	2
Iowa	2	South Dakota	1
Japan	1	Tennessee	2
Louisiana	1	Utah	2
Massachusetts	5	Washington	3
Mexico	2	Wisconsin	6

Table III presents the classified vocations of the engineer alumni, also average salaries or income.

TABLE III.

Classified vocation of engineer alumni.

Vocations.	Number.	Average salaries.	Number reporting salaries.
Presidents, secretaries, managers, etc	21	$2,697	12
Executive—technical, consulting, teaching, etc	64	2,564	57
Superintendents, foremen, chief draftsmen, inspectors, etc	68	1,598	60
Assistants, draftsmen, apprentices, clerical, etc	33	1,239	29
Non-engineering	10	2,550	8
Total	196	.....	.....

*Based on information furnished by 196 out of 269 graduates in the classes '88 to '07 inclusive. Classes '08 and '09 not considered on account of frequent changes in position.

Table IV gives the average earnings by classes.

TABLE IV.

Average salaries by classes.

Class of '07	$1,299	32 reporting out of 44.
Class of '06	1,569	33 reporting out of 42.
Class of '05	1,635	17 reporting out of 26.
Class of '04	1,481	16 reporting out of 19.
Class of '03	1,913	11 reporting out of 26.
Class of '02	2,250	5 reporting out of 20.

N. B.—All of the above is based on information received from January 1, to May 23, 1910.

In so far as statistics alone can be used the conclusions to be drawn from the records of our engineer alumni are very gratifying and indicate that the engineering work at the College has justified its establishment and maintenance.

The Future.

In order that the same statement may be made with like force at the end of another quarter century constant and insistent attention must be given by the College, not only to the course of study and its development in step with the advancing ideas as to the requisites of technical education, but particularly to the question of *efficiency* of *instruction*. With the growth of the College this problem becomes of greater and greater moment, because the student is removed more and more from personal influence and teaching of the strong men of the faculty who are largely engaged in the necessary administrative work which goes with large schools and departments.

The handling of large classes by inexperienced instructors, as is now the policy here, does not bridge the distance between the student and the professor, but rather the reverse. It is important that many men of assistant professor grade or higher, with commensurate salaries be added to our teaching force and that good teachers once obtained be secured by salary or other inducements such as opportunity for research or commercial work in reasonable amount, against the allurements of commercial positions.

I strongly recommend, as I have done in previous reports:

(a) An advanced salary scale for the various grades of instructors.

(b) The formal recognition and inauguration of experiment station work in engineering as important measures for the maintenance of the engineering work of the College on a satisfactory plane.

Respectfully submitted,

G. W. BISSELL,
Dean of Engineering.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF MECHANICAL ENGINEERING.

East Lansing, Mich., July 1, 1910.

Dr. J. L. Snyder, President, Michigan Agricultural College.

Dear Sir: I present, herewith, my report as professor of mechanical engineering for the fiscal year ending June 30, 1910.

At the beginning of the year, the teaching and administrative staff of the department was as follows:

G. W. Bissell, Professor.
L. L. Appleyard, Assistant Professor.
J. A. Polson, Assistant Professor.
C. C. Wilcox, Instructor.
W. H. Hartman, Instructor.
A. P. Krentel, Instructor.
E. C. Baker, Instructor.
W. R. Holmes, Instructor.
A. Smith, Instructor.
H. P. Case, Instructor.
Miss C. B. Purcell, Clerk.

In addition, Mr. J. N. Bidwell and Mr. T. M. Hooper of the senior class were employed to assist in handling the large classes in machine design and engineering laboratory.

In the winter term, Mr. Case resigned to accept a more lucrative position in a Lansing shop. Mr. C. L. Brackett was appointed in his place.

Shortly before the close of the college year, Mr. Wilcox resigned to accept a commercial position at a substantial advance in salary and for better prospects of promotion than the College could offer. His place has not yet been filled.

The principal additions to the material equipment of the department during the year were as follows:

1—50 H. P. Tandam Gas Engine.
1—Flue Gas Recorder.

1—Tortion Testing Machine.
1—6-in. Centrifugal Pump.
1—Universal Grinder for Woodworking Tools.
1—Tool Room Lathe.

The department acknowledges the donations of complete demonstration models of automatic temperature control apparatus from the Powers Regulator Co., the Johnson Service Co., and the National Regulator Co.

I am pleased to testify to the earnest coöperation of all members of the department staff in the work of the year and regret the changes caused by the allurements of commercial positions which we cannot successfully combat under the scale of salaries now in force at the College. Subjoined is a schedule of the class duties of the department staff for each term of the past year.

Respectfully submitted,
G. W. BISSELL,
Professor of Mechanical Engineering.

East Lansing, June 30, 1910.

Class-work of Department of Mechanical Engineering, Fall Term, 1909.

TABLE I.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled.	Student hours per week.
Sub-freshmen	Wood-shop	2 m	Mr. Krentel Mr. Smith	4	70	280
4-year freshmen	Wood-shop	2 a	Mr. Krentel Mr. Smith	8	129	1,032
5-year freshmen	Wood-shop	2 p	Mr. Krentel Mr. Smith	8 4	47	188
Sophomores	Forge-shop	2 d	Mr. Holmes	8	69	552
Sophomores	Foundry	2 f	Mr. Baker	8	52	416
Juniors and seniors	Machine-shop	2 h, 2 k	Mr. Wilcox Mr. Case	8	59	472
Juniors	Machine design	6 c	Mr. Hartman	6	28	168
Juniors	Metallurgy	11 a	Prof. Polson Mr. Wilcox	2	70	140
Seniors	Steam engine design	8 b	Prof. Appleyard	6	18	108
Seniors	Kinematics	14 a	Prof. Appleyard	2	33	66
Seniors	Experimental lab.	15 a	Prof. Polson	4	38	152
Seniors	Graphics of mechanism.	16	Mr. Hartman	4	40	160
Seniors	Thermo-dynamics	17	Prof. Bissell	5	46	230
Totals					699	3,964

Class-work of Department of Mechanical Engineering, Winter Term, 1910.

TABLE II.

Class.	Subject.	No. of course.	Teacher.	Hours per week. each student.	No. of students enrolled.	Student hours per week.
Sub-freshmen	Wood-shop	2 n	Mr. Krentel Mr. Smith	4	68	272
4-year freshmen	Wood-shop	2 b	Mr. Krentel Mr. Smith	8	112	896
5-year freshmen	Wood-shop	2 q	Mr. Krentel Mr. Smith	4	44	176
4-year and 5-year freshmen	Elements of engineering	1	Prof. Bissell	2	172	344
Sophomores	Forge-shop	2 e	Mr. Holmes	8	54	432
Sophomores	Foundry	2 f	Mr. Baker	8	46	368
Sophomores	Machine design	6 a	Mr. Hartman Mr. Bidwell	6	99	594
Juniors and seniors	Machine shop	2i, 2 l	Mr. Wilcox Mr. Case	8	66	528
Juniors	Machine design	6 d	Mr. Hartman	6	29	174
Juniors	Steam engine	7 a	Prof. Appleyard Mr. Wilcox	5	75	375
Juniors	Engineering lab.	13 a	Prof. Polson Mr. Hooper	4	62	248
Seniors	Machine design	6 e	Prof. Appleyard	8	18	144
Seniors	Power station design	21	Prof. Bissell	7	24	168
Seniors	Engineering laboratory.	15 b	Prof. Polson Mr. Hooper	8	13	104
Totals					882	4,813

Class-work of Department of Mechanical Engineering, Spring Term, 1910.

TABLE III.

Class.	Subject.	No. of course.	Teacher.	Hours per week each student.	No. of students enrolled.	Student. hours per week.
Sub-freshmen	Wood-shop	2 o	Mr. Krentel Mr. Smith	4	51	204
4-year freshmen	Wood-shop	2 c	Mr. Krentel Mr. Smith	8	97	776
5-year freshmen	Wood-shop	2 r	Mr. Krentel Mr. Smith	4	39	156
Sophomores	Forge-shop	2 e	Mr. Holmes	8	44	352
Sophomores	Foundry	2 g	Mr. Baker	8	53	424
Sophomores	Machine design	6 b	Prof. Appleyard Mr. Hooper	4	97	388
Juniors	Machine shop	2 j	Mr. Wilcox Mr. Brackett	8	61	488
Juniors	Thermodynamics	17 a	Prof. Bissell Prof. Polson Mr. Wilcox	3	56	168
Juniors	Materials laboratory	13 b	Prof. Polson Mr. Hooper	4	61	244
Juniors	Kinematics	22	Prof. Appleyard	2	68	136
Seniors	Gas engine design	6 f	Mr. Hartman	6	9	54
Seniors	Engineering practice	18	Prof. Bissell	2	18	36
Seniors	Thesis	19	Prof. Bissell Prof. Polson	10	8	80
Totals					662	3,506

REPORT OF THE DEPARTMENT OF CIVIL ENGINEERING.

To the President:

Dear Sir: As recommended in my last report the former department of mathematics and civil engineering was officially divided by resolution of the Board of Agriculture, and since September first, 1909, I have been concerned only with the department of civil engineering of which I was continued in charge. At your request during the summer of 1909 I nominally attended to the designation of new instructors in mathematics whom it was necessary to engage, but the real selection of these men was left with Professor Babcock, whose choice I approved in every case. His report will no doubt amply detail the history of the appointments made in mathematics. What follows here deals only with the new department of civil engineering.

At the beginning of the fall term the departmental staff consisted of the following teachers, whose names are given in order of seniority of appointment:

H. K. Vedder, C. E., Professor of Civil Engineering.
W. B. Wendt, B. C. E., Instructor in Civil Engineering.
L. S. Fuller, B. S., Instructor in Civil Engineering.
A. S. Rosing, B. S. in C. E., Assistant Professor of Civil Engineering.
C. N. Wilson, B. C. E., Instructor in Civil Engineering.
J. T. Buser, B. S. in C. E., Instructor in Civil Engineering.

Shortly after the opening of the spring term of 1910, Instructor Wilson received an appointment to the U. S. army, and he requested that he be allowed to relinquish his contract with the college and this department. To direct the classes which had been assigned to Mr. Wilson, we secured Mr. Oscar Fairbanks, B. S., temporarily as instructor and he assumed his duties April 25th, while Mr. Wilson withdrew on April 24th. Mr. Fairbanks finished his assignments and terminated his engagement on June 25th.

The unprecedented number of classes scheduled for the spring term in the field work of land surveying, topographical and railroad surveying, demanded additional assistance in this work. Accordingly, Mr. J. E. Wilcox was engaged as instructor for the definite period of three months, April to June inclusive. The volume of field work really called for two extra assistants, but we were allowed only one. As a consequence, some of the sectional assignments were too large for very efficient instruction or satisfactory results. In partial mitigation of these conditions the mechanical department very kindly extended us acceptable assistance by giving us the services of Mr. Hartman for one day of each week during the spring term.

Besides Mr. Wilson, another member of our regular staff has resigned and will leave at the close of the college year. This is Mr. L. S. Fuller, who intends to engage in practical engineering.

A series of civil engineering studies were first available to the class

which graduated in 1903. I think it is not generally known that of all engineering graduates since that time a majority have been those who have elected their major work in civil engineering. At the commencement of 1910, twenty-four young men received diplomas who have completed this line of training, a larger group than can be claimed by any other department of the technical specialization at the college. These facts, together with the assured increase in demand for this kind of instruction at least for several years to come, reasonably call for the adequate provision of competent teachers. I would recommend the appointment of teachers who have had successful practical experience; and I would like to remind you of certain reflections along this line in my last report, which may be considered as repeated here and with emphasis. Further in this connection, permit me to express the opinion that we need specialists trained by experience to deal most satisfactorily with the earlier studies in engineering. Indeed I am inclined to believe that if shift must be made to get along with inadequate resources, it would be serving educational purposes better to invert the usual order, and place our most experienced instructors in charge of the earlier and most fundamental studies. When the time arrives that the simplest, most elementary principles shall be presented by those who have had extensive practice in applying them, then we may look for the ideally prepared beginner in engineering.

Either the suggested assignment by inversion, or the better plan of perfectly competent teachers at every stage of instruction will be seen to require an increasing budget for maintenance, as long as the engineering side of this institution continues to grow. I hope this department may be treated ever more generously in the apportionment of funds for securing capable teachers and for retaining them when their efficiency is established.

Continuing my time-honored custom, I present herewith a table showing the work of teaching carried out by this department during the year; it will answer questions of enrollment, assignments, classrooms occupied, size of sections, and the like.

In presenting such a tabulation I wish to make it plain that it presents only a partial record of the almost innumerable duties devolving upon our teachers and more particularly upon the older ones. Aside from the half-time service of a stenographer, the department has had no pay roll except the regular staff.

Class work of the department of civil engineering for the college year 1909-1910.

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. hours per week.	No. of students in class.
Summer School '09.							
Juniors	Surveying methods	C. E. 2a	Mr. Wendt	111 Eng. Bldg.		8	15
Seniors	Topog. mapping	C. E. 6a	Mr. Wendt	304 Eng. Bldg.		8	4
Totals	2 sections					16	19
Fall term.							
Juniors	Mech. of Eng	C.E. 4a.	Mr. Fuller	203 Eng. Bldg.	8–9	5	15
Juniors	Mech. of Eng	C.E. 4a.	Mr. Fuller	111 Eng. Bldg.	10–11	5	12
Juniors	Mech. of Eng	C.E. 4a.	Mr. Wendt	203 Eng. Bldg.	11–12	5	16
Juniors	Mech. of Eng	C.E. 4a.	Mr. Wilson	302 Eng. Bldg.	8–9	5	22
Juniors	Adv. Surveying (class)	C. E. 6.	Mr. Buser	203 Eng. Bldg.	9–10	3	16
Juniors	Adv. Surveying (class)	C.E. 6..	Mr. Wilson	302 Eng. Bldg.	9–10	3	14
Juniors	Adv. Surveying (field)	C.E. 6..	Mr. Wendt, Buser, Wilson	111 Eng. Bldg.	1–3	4	30
Juniors	Adv. Surveying (class)	C.E. 6..	Mr. Buser	111 Eng. Bldg.	11–12	3	22
Juniors	Adv. Surveying (class)	C.E. 6..	Mr. Wilson	203 Eng. Bldg.	11–12	3	17
Juniors	Adv. Surveying (field)	C.E. 6..	Mr. Wendt, Buser, Wilson	203 Eng. Bldg.	1–3	4	39
Seniors	Surveying methods (class)	C.E. 2..	Mr. Wendt	111 Eng. Bldg.	8–9	3	28
Seniors	Surveying methods (field)	C.E. 2..	Prof. Vedder, Mr. Wendt	111 Eng. Bldg.	8–10	4	28
Seniors	Graphic Statics	C.E. 4d.	Prof. Rosing	111 Eng. Bldg.	9–10	3	20
Seniors	Graphic Statics	C.E. 4d.	Prof. Rosing	111–301 Eng. Bldg.	8–9	3	20
Seniors	Railroad Surveying	C.E. 7..	Prof. Rosing, Mr. Fuller	111–106 Eng. Bldg.	1–5	8	24
Seniors	Bridge Stresses	C.E. 8a.	Prof. Vedder	109 Eng. Bldg.	10–11	3	13
Seniors	Bridge Stresses	C.E. 8a.	Prof. Vedder	109 Eng. Bldg.	11–12	3	12
Totals	17 sections					67	348

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. hours per week.	No. of students in class.
Winter term.							
Juniors	Mech. of Eng	C.E. 4b.	Mr. Buser	401 Eng. Bldg.	8–9	5	15
Juniors	Mech. of Eng	C.E. 4b.	Mr. Wilson	302 Eng. Bldg.	8–9	5	16
Juniors	Mech. of Eng	C.E. 4b.	Mr. Wilson	302 Eng Bldg	1–2	5	15
Juniors	Mech. of Eng	C.E. 4b.	Mr. Wilson	302 Eng. Bldg.	2–3	5	15
Seniors	Agr. Eng	C.E. 3..	Prof. Vedder	111 Eng. Bldg.	9–10	5	28
Seniors	Hydraulics	C.E. 5..	Prof. Rosing	203 Eng. Bldg.	8–9	5	8
Seniors	Hydraulics	C.E. 5..	Mr. Wendt	111 Eng. Bldg.	8–9	5	10
Seniors	Hydraulic Lab	C.E. 5a.	Prof. Rosing, Mr. Fuller	3 Eng. Bldg.	1–5	4	10
Seniors	Hydraulic Lab	C.E. 5a.	Prof. Rosing, Mr. Fuller	3 Eng. Bldg.	1–5	4	8
Seniors	Bridge Design	C.E. 8b.	Prof. Vedder, Mr. Fuller	304–306 Eng. Bldg.	10–12	8	25
Seniors	Experimental Lab	C.E. 12.	Mr. Wendt, Mr. Buser	4–106 Eng. Bldg.	1–5	8	14
Seniors	Experimental Lab	C.E. 12.	Mr. Wendt, Mr. Buser	4–106 Eng. Bldg.	1–5	8	14
Seniors	Water supply, sewerage	C.E. 15.	Prof. Rosing	203 Eng. Bldg.	9–10	5	19
Totals	13 sections					72	197

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. hours per week.	No. of students in class.
Spring term.							
Sophomores.	Surveying (class).....	C.E. 1a.	Prof. Vedder.....	111 Eng. Bldg....	8–9	2	47
Sophomores.	Surveying (class).....	C.E. 1a.	Prof. Vedder.....	111 Eng. Bldg....	8–9	2	41
Sophomores.	Surveying (field).....	C.E. 1a.	Mr. Buser, Mr. Wilcox...	111 Eng. Bldg....	1–3	2	47
Sophomores.	Surveying (field).....	C.E. 1a.	Mr. Buser, Mr. Wilcox...	111 Eng. Bldg....	10–12	2	41
Sophomores.	Surveying, leveling (class)	C.E. 1b.	Mr. Buser.....	203 Eng. Bldg....	10–11	2	31
Sophomores.	Surveying, leveling (field)	C.E. 1b.	Mr. Buser.....	203 Eng. Bldg....	8–10	4	31
Sophomores.	Surveying, leveling (class)	C.E. 1b.	Mr. Buser.....	302 Eng. Bldg....	10–11	2	23
Sophomores.	Surveying, leveling (field).	C.E. 1b.	Mr. Buser.....	302 Eng. Bldg....	8–10	4	23
Sophomores.	Surveying, leveling (class)	C.E. 1b.	Mr. Fairbanks.....	203 Eng. Bldg....	2–3	2	23
Sophomores.	Surveying, leveling (field).	C.E 1b.	Mr. Fairbanks, Mr.Buser..	111 Eng. Bldg....	3–5	4	23
Sophomores.	Surveying, leveling (class)	C.E. 1b.	Mr. Wendt.....	203 Eng. Bldg....	2–3	2	27
Sophomores.	Surveying, leveling (field).	C.E. 1b.	Mr. Fuller, Mr. Buser....	111 Eng. Bldg....	3–5	4	27
Juniors.....	Str. of materials.....	C.E. 4c.	Mr. Fairbanks.....	302 Eng. Bldg....	1–2	5	14
Juniors.....	Str. of materials.....	C.E. 4c.	Mr. Fairbanks.....	203 Eng. Bldg....	9–10	5	20
Juniors.....	Str. of materials.....	C.E. 4c.	Mr. Fuller.....	111 Eng. Bldg....	9–10	5	15
Juniors.....	Str. of materials.....	C.E. 4c.	Mr. Fuller.....	203 Eng. Bldg....	1–2	5	14
Juniors.....	Topog. mapping.....	C.E. 6a.	Mr. Fuller.....	306 Eng. Bldg....	10–12	4	18
Juniors.....	Topog. mapping.....	C.E. 6a.	Mr. Fuller.....	306 Eng. Bldg....	3–5	4	23
Juniors.....	R. R. surveying (class)...	C.E. 7..	Prof. Rosing.....	203 Eng. Bldg....	8–9	3	22
Juniors.....	R. R. surveying (field)...	C.E. 7..	Prof. Rosing, Mr.Hartman	109–401 Eng. Bldg.	1–5	4	22
Juniors.....	R. R. surveying (class)...	C.E. 7..	Prof. Rosing.....	111 Eng. Bldg....	2–3	3	22
Juniors.....	R. R. surveying (field)...	C.E. 7..	Prof. Rosing, Mr. Hartman	401 Eng. Bldg.....	8–12	4	22
Seniors.....	Topog. surveying (class)..	C.E. 2a.	Mr. Wendt.....	301 Eng. Bldg....	1–2	3	25
Seniors.....	Topog. surveying (field)..	C.E. 2a.	Mr. Wendt.....	111 Eng. Bldg....	8–12	4	25
Seniors.....	Adv. surveying (class)....	C.E. 6..	Mr. Wendt.....	109 Eng. Bldg....	11–12	3	20
Seniors.....	Adv. surveying..(field)...	C.E. 6..	Mr. Wendt.....	302 Eng. Bldg....	2–5	6	20
Seniors.....	Masonry and arches.....	C.E. 9..	Mr. Wendt.....	304 Eng. Bldg....	8–10	8	21
Seniors.....	Pavements.....	C.E. 10.	Prof. Vedder.....	111 Eng. Bldg....	11–12	2	22
Seniors.....	Theses.....	C.E. 11.	Prof Vedder.....	106 Eng. Bldg....	1–5	10	23
Seniors.....	Contracts and Specif.....	C.E. 13.	Prof. Vedder.....	111 Eng. Bldg....	11–12	2	22
Seniors.....	Road construction (class).	C.E. 17	Prof. Rosing.....	203 Eng. Bldg....	11–12	2	16
Seniors.....	Road construction (field).	C.E. 17.	Prof. Rosing.....	401 Eng. Bldg....	10–12	6	16
Totals..	32 sections.....	.....	.....	.....	.....	120	786

Our scheduled work in classes, field and laboratories is not well divided among the three terms of the year. There are a number of reasons for this unfortunate condition of things and despite studious efforts toward a better equalization of periods we have not been able to secure the desired result. Almost every subject in our departmental list depends upon other prerequisite studies, thus the year and term for each are quite narrowly limited. Besides this, our out-door field work cannot be efficiently conducted in the winter term.

The following text books have been used in our classes during the year: Allen's Railroad Curves and Earthwork; Merriman and Jacoby's Roofs and Bridges, Vols. I, II, III; Hodgman's Land Surveying and Vedder's Notes on Surveying; Church's Mechanics; Baker's Masonry Construction; Johnson's Theory and Practice of Surveying; Waddell & Wait's Specifications and Contracts; Baker's Roads and Pavements; Merriman's Treatise on Hydraulics; Waterbury's Cement Lab. Manual; Turneaure & Russell's Public Water Supplies; Folwell's Sewerage; Wilson's Topographic Surveying.

The total expenditure by the department during the year for all pur-

poses has been $3,952.45 of which $43 was turned in for special examinations, and $463.40 for laboratory fees and other departmental receipts.

Respectfully submitted,

H. K. VEDDER,

Professor Civil Engineering.

East Lansing, Mich., June 30, 1910.

REPORT OF THE DEPARTMENT OF PHYSICS AND ELECTRICAL ENGINEERING.

President J. L. Snyder:

Dear Sir: The year 1909-1910 has been one of the most satisfactory years that this department has ever experienced. We had fairly good equipment and a very good corps of instructors, and I think without exception all the classes have been held as per the schedule.

For the first time in several years some of the students in agriculture and forestry have elected work in advanced physics. It is put down in the catalogue as physics 4a and 4c. I conducted both of the classes myself and had some eight or nine students. It is perhaps unnecessary to say that they were not particularly interested in advanced physics and consequently the work which was given was more along the line of the practical application of the principles to their work. "Four a" was made a subject of electrical engineering, while 4c was made a study of the application of mechanics and mechanical principles to power work on the farm and proved very interesting and profitable to both the students and the instructor.

The teaching force is a trifle different from the year before. Mr. W. L. Lodge, Assistant Professor of physics, has had the mechanical engineering sophomores while Mr. Ernest Roller has had the college work of the agricultural and forestry students. Mr. H. E. Marsh and Mr. W. E. Laycock have assisted the above men and given the preparatory work entirely. Mr. G. A. Kelsall has taken the place formerly held by Mr. Bates and has given very satisfactory service indeed.

For the first time this year all advanced engineering students have taken some work in electrical engineering which has increased the number of students in the department of electrical engineering very materially.

Below is a table showing the work carried by this department during the year.

Class.	Subject.	Instructor.	Sections for lectures.	Sections for recitations.	Sections for laboratory.	Hours per week.	Number of students.
Fall term.							
Sub-freshmen	Physics 2a	Mr. Laycock		2		3	40
Sub-freshmen	Physics 2a	Mr. Marsh		2		3	44
Sophomores	Pnysics 2d	Mr. Lodge		4		4	103
Sophomores	Physics 2d	Mr. Marsh			4	4	95
Sophomores	Physics 3e	Mr. Lodge		2		3	46
Sophomores	Physics 3e	Mr Laycock			4	4	44
Sophomores	Physics 1e	Mr. Roller	1	4	6	2 2 2	90
Juniors	E. E. 1a	Prof. Sawyer		2		1	26
Juniors	E. E. 1a	Mr. Kelsall			2	4	26
Juniors	E. E. 6a	Prof. Sawyer		1		1	39
Juniors	E. E. 6a	Mr. Kelsall		2		3	39
Juniors	E. E. 4a	Mr. Kelsall			2	4	26
Seniors	E. E. 3a	Prof. Sawyer		1		3	15
Seniors	Physics 4a	Prof. Sawyer		1	1	4 2	8

Class.	Subject.	Instructor.	Sections for lectures.	Sections for recitations.	Sections for laboratory.	Hours per week.	Number of students.
Winter term.							
Sub-freshmen	Physics 2b	Mr. Laycock	1	4		2	70
Sub-freshmen	Physics 2b	Mr. Carpenter			5	1 2	70
Sub-freshmen	Physics 3a	Mr. Laycock	1	2		1 4	40
Sub-freshmen	Physics 3a	Mr. Marsh			3	2	35
Sub-freshmen	Physics 1a	Mr. Marsh	1	4		1 3	68
Sub-freshmen	Physics 1a	Mr. Carpenter			3	2	68
Sophomores	Physics 2e	Mr. Lodge		4	4	4 2	84
Sophomores	Physics 2e	Mr. Laycock			3	2	40
Sophomores	Physics 1f	Mr. Roller	1	4	4	2 2 2	85
Juniors	E. E. 1b	Prof. Sawyer		2		3	25
Juniors	E. E. 1b	Mr. Allett			1	4	25
Juniors	E. E. 6b	Mr. Lodge			1	2	9
Juniors	E. E. 6b	Mr. Kelsall		2		2	35
Juniors	E. E. 6b	Mr. Kelsall			2	2	19
Juniors	E. E. 1b	Mr. Allett			4	2	25
Seniors	E. E. 2b	Prof. Sawyer		1		5	15
Seniors	E. E. 2b	Mr. Kelsall			2	4	15
Seniors	E. E. 5a	Mr. Kelsall		1	1	5 4	8

Class.	Subject.	Instructor.	Sections for lectures.	Sections for recitations.	Sections for laboratory.	Hours per week.	Number of students.
Spring term.							
Sub-freshmen	Physics 2c	Mr. Laycock	1	3	1	1 3 2	74
Sub-freshmen	Physics 2c	Mr. Carpenter			3	2	47
Sub-freshmen	Physics 3b	Mr. Laycock	1	2	2	1 4 2	73
Sub-freshmen	Physics 1b	Mr. Marsh	1	4	4	1 3 2	48
Sub-freshmen	Physics 1b	Mr. Carpenter			4	2	51
Freshmen	Physics 1d	Mr. Roller		8	8	1 2	142
Freshmen	Physics 3d	Mr. Marsh	1	4	2	1 1 2	55
Freshmen	Physics 3d	Mr. Carpenter			2	2	22
Sophomores	Physics 2f	Mr. Kelsall			3	2	40
Sophomores	Physics 2f	Mr. Lodge		4	4	4 2	85
Juniors	E. E. 1c	Prof. Sawyer		2		3	27
Juniors	E. E. 1c	Mr. Kelsall			2	4	27
Seniors	E. E. 8	Prof. Sawyer		1	1	2 4	8
Seniors	Physics 4c	Prof. Sawyer		1	1	2 2	6

Respectfully,

A. R. SAWYER,

Professor of Physics and Electrical Engineering.

East Lansing, Mich., June 30, 1910.

REPORT OF THE DEPARTMENT OF DRAWING AND DESIGN.

President J. L. Snyder:

Dear Sir: I herewith beg leave to submit to you my second annual report as head of the Department of Drawing and Design for the year ending June 30, 1910.

The work of the department has been carried on substantially as outlined in my last report. I foresee certain desirable changes in methods of administration due to the increase in attendance, and consequent increase in instructing staff, and it has been my effort this year to so systematize the department work that it may run automatically and with least difficulty in initiating new instructors yearly. I am trying to make the outline of courses specific and put in such form that new instructors will follow easily in the paths of their predecessors.

The responsibility for the various lines of the teaching is divided up as outlined in my last report and is proving a very satisfactory plan. I personally this year have been more in touch with the freehand drawing, having taken classes in it and studied it from the inside.

As a result of my observation of the work and the students taking it I wish here to continue my suggestion of the desirability of establishing at some early date a course in Industrial Art which may be intimately

related to the Household Science course, namely—a course open principally to women and in which the studies are divided appropriately between the sciences and drawing, the latter taking the place of the present household science studies. A student thus equipped would be able to fill the ever increasing demand for teachers of drawing in the state and also be able to take up the practice of drawing, chiefly in the lines of applied design. There is no school at present in the state which adequately provides such a course and there seems to be a legitimate opening here for such. It would give another option for the women who did not care to make a specialty of household science.

I am also impelled to make this strong appeal because of some probable department changes in the near future which makes it necessary to plan ahead. The expense for such a course would, considering its importance, be very slight. The regular department equipment would be sufficient and the only main expense would be for a teacher who has the educational equipment to cope with the important work. For the present at least no additional teachers would be necessary.

The new course in design, as outlined in my last report was continued with popularity and success making the above suggestion likely to meet with favor among the women at least.

The work of teaching has been carried on as follows by teachers named in the order of seniority of appointment:

Ass't. Prof. Chace Newman, in charge of the mechanical drawing courses.

Miss Caroline Holt, in charge of the freehand drawing classes.

Miss Isabel Snelgrove, instructor in freehand drawing.

All of the above have rendered continued satisfactory services and are deserving of proper recognition. No higher loyalty and faithfulness to the best interests of the college and the students could have been expected of them.

Mr. Chas. C. Cobb, graduated as B. S. in Engineering, from this college in 1909, and who had been acting as an assistant instructor the previous year, became an instructor in mechanical drawing and did excellent, capable, and faithful service. We regret that he leaves us to go into more profitable practical work.

Mr. Paul N. Ford, B. S. in C. E. and Master in C. E., Cornell College, Iowa, 1909, having had quite extended practical experience for a young man, being Ass't. Engineer in the State Engineer's office of N. Dakota and a like position in the City Engineer's office S. Dakota, took charge of the courses in civil engineering drawing and did also excellent and capable service and he likewise we regret to say has been attracted by higher salary in practical work.

Mr. Fritz G. Cornell, student in agriculture, was continued on the staff as an assistant in mechanical drawing, teaching during the fall and winter terms.

Miss Bessie Bartholomew, who is a resident of Lansing and who has taught in the public schools, was engaged as an assistant sixteen hours a week during the fall term when an unexpected increase in numbers of the agricultural students made it necessary for efficient teaching to divide the classes into halves. She gave very satisfactory service.

In fact the esprit-de-corps of the staff has been excellent as I have had occasion before to observe. I wish here to put in a plea for a better financial recognition for valuable services. Yearly it is becoming more difficult to hold and to even obtain capable teachers, so patent are the advantages in practical work. An increase of 10 to 20 per cent in financial remuneration would undoubtedly show a very much larger percentage of increase in teaching efficiency and educational value to the college.

There has been some increase in equipment made necessary by increase in attendance,—lockers, etc., which have been built by a student, thus helping the latter to make his way. We are trying to employ student labor as much as possible in all work. Steps have been taken to provide decoration of the class room walls with drawings representative of the various drawing courses. We hope to complete this in time, and add very much to the attractiveness of the rooms.

The annual exhibit of public school drawings was held again this year with continued success. I hope in time that this may become a very valuable adjunct of the college work. It seems as though the drawing department should cooperate with the educational interests of the state along its line.

Drawing department.

Class.	Subject.	Instructor.	Fall.		Winter.		Spring.	
			Term.	Term.	Term.	Term.	Term.	Term.
Sub-freshman—Ags	1. Free-hand drawing	Miss Holt	4	34				
		Miss Snelgrove	4	30				
Sub-freshman—Ags	1a. Free-hand drawing	Miss Snelgrove			4	31		
		Miss Snelgrove			4	25		
Sub-freshman—Engineers	Mech. drawing	Prof. Newman	6	17				
		C. C. Cobb	6	17	6	19	6	27
	Fall term 4ac	C. C. Cobb	6	16				
	Winter term 4d	P. N. Ford			6	18	6	23
	Spring term 4f	F. G. Cornell	6	18	6	18		
Sub-freshman—H. E	1a. Free-hand drawing	Miss Snelgrove					4	24
Freshman—Ags	1c. Free-hand drawing	Miss Holt	4	19				
		Miss Holt	4	19				
		Miss Snelgrove	4	18				
		Miss Snelgrove	4	19				
		Miss Bartholomew	4	20				
		Miss Bartholomew	4	19				
		Miss Bartholomew	4	19				
		Miss Bartholomew	4	19				
Freshman—Engineers	Mech. drawing	Prof. Wilson					5	15
	Fall term 4ab	Prof. Newman	6	35	8	26	5	24
	Winter term 4e	Prof. Newman					5	22
	Spring term, Desc. Geom. 5a	C. C. Cobb	3	34			5	29
		C. C. Cobb			8	31	5	21
		C. C. Cobb			8	31	5	27
		P. N. Ford	3	34				
		P. N. Ford	6	27	8	26		
		P. N. Ford			2	5		
Freshman—H. E	1b. Free-hand drawing	Prof. Wilson	6	21	4	21		
		Miss Holt	6	21	4	19		
	Winter term 1d	Miss Snelgrove	6	23	4	16		
		Miss Snelgrove	6	17				
		Miss Snelgrove			4	21		
Sophomore—Ags	3b. Mech. drawing lecture	Prof. Wilson					3	19
		Prof Wilson					3	28
		Prof. Wilson					3	8
		Miss Snelgrove					6	20
		Miss Snelgrove					6	29
		Miss Snelgrove					6	8
		P. N. Ford					6	29
Sophomore—Engineers	5b. Desc. Geom	Prof. Wilson	5	29				
		Prof. Newman	5	29				
		Prof. Newman	5	24	4	9		
		C. C. Cobb	5	25				
Sophomore—H. E	2a. Hist. of Art	Miss Holt					5	24
		Miss Holt					5	20
	3a. Mech. drawing	Miss Holt					4	27
		Miss Holt					4	20
Junior Ags	3c. Topographical drawing	P. N. Ford					10	22
Junior Engineers	6. Topographical drawing	P. N. Ford	6	22				
Junior Engineers	6. Topographical drawing	P. N. Ford	6	18				
Junior and Senior Engineers	7. Shades and Shadows	Prof. Newman			6	24		
		P. N. Ford			6	23		
Junior and Senior H. E	2b. Hist. of Art	Miss Holt			5	16		
	1e. Free-hand drawing	Miss Holt	4	1				

Very respectfully submitted

REPORT OF THE DEPARTMENT OF FORESTRY.

To the President:

I herewith present my report as Professor of Forestry for the year ending June 30, 1910.

COURSE OF STUDY.

The course of study as set forth in the College catalogue for 1908 and 9 was followed with the exception of the summer term of the senior year. The enrollment for the subjects presented by terms may be tabulated as follows:

Year.	1908-9.	1909-10.
Summer		19
Fall	66	97
Winter	86	89
Spring	131	172
	283	377

The summer term was held at the College during a period of four weeks. Two weeks were given up to Civil Engineering 2 and two weeks to Forestry 3 (Forest Mensuration) . This summer term is of great benefit for in no other way can the student get so much practical field work in the subjects presented.

Through the invitation of the Salling and Hanson Lumber Company of Grayling, Michigan, the senior class in Forestry 12 (Lumbering) spent two weeks in their camps at Frederic studying conditions and methods during the month of December, 1909.

By the kindness and courtesy of the State Public Domain Commission, the summer term for 1910, is now being held at Cold Springs on the shores of Higgins Lake, Roscommon county, Michigan. Here the students are on the state forest of 38,000 acres of variously timbered cut over lands so common in the north central portion of the state. The subjects presented are the same as those taken up last year, i. e., Civil Engineering 2 and Forestry 3 (Forest Mensuration). The work extends over a period of six weeks. There is a large well lighted class room furnished with black boards and laboratory tables. Twenty-four students are classified and are now in camp at work. They are housed in tents, two men to a tent. The tents are walled tents 9½x12 feet, furnished with a board floor, two iron beds with mattresses, a small table, two chairs and a lantern. Each student furnishes his own bedding. Oil and matches are furnished without charge to the students. Four boats are also for the use of the students after work hours. Board is furnished at $3.50 per week.

FOREST EXTENSION WORK.

The applications for examination of wood lots during the past year have been more numerous than ever before, but owing to lack of a field

forester no examinations have been made. These applications have been classified and filed for future reference.

The number of trees distributed to those interested in forestry are as follows: Conifers, 149,782; Broad leaf, 172,385; total, 322,167. The major portion of this stock was distributed gratis to schools, townships, cemeteries, exchanges and public parks. Estimated amount of tree stock now on hand in seed beds and nursery row is as follows: Conifers, 4,060,289; Broad leaf, 152,440.

During the past year 1,992 letters have been sent out from the department.

The A. A. Sprogis Company of Gleason, Wisconsin, have placed in the department a set of their logger flexible safety grab hooks for exhibit and demonstration purposes. These instruments add greatly to the large assortment of logging tools and equipment for exhibit and demonstration purposes already on hand.

Very respectfully submitted,

J. FRED BAKER,
Professor of Forestry.

East Lansing, June 30, 1910.

REPORT OF THE DEAN OF HOME ECONOMICS.

To President J. L. Snyder, Michigan Agricultural College:

Dear Sir: I herewith present my report as Dean of Home Economics for the year 1909-10.

The personnel of the department teaching force remained the same as for the preceding year, with the exception of the assistant in music. Domestic art,—Miss Kate M. Coad, Miss Rosamond Kedzie and Mrs. L. L. Peppard; domestic science,—Miss Pearl MacDonald, Mrs. Peppard and Mrs. Martha Barber, (lecturer on home nursing); ethics,—Miss Gilchrist; Music,—Miss Louise Freyhofer, Miss Edna B. Hopson and Miss Eloise C. Hall assistant in fall and Mrs. E. I. Dail in winter term; physical training,—Miss Mabel Long.

A new officer was added to our staff the first of September, Mrs. Katherine Morse Cameron as House Director. The duties of the office are similar to those of matron, and include the care of the sick, charge of the kitchen and dining room, direction of the help, general care of the house, etc. The wisdom of this appointment was soon manifest since the senior instructor in domestic science was thus able to devote most of her time to class work and the duties of the dean's office were lessened.

At the beginning of the year one hundred sixteen students were placed in the Women's Building, and twenty-seven in Howard Terrace, the building adjacent on the west. The use of the Terrace gave also three much needed additional practice rooms for the fall and winter terms.

In the spring term the domestic art department gave work, as heretofore, in sewing to the girls in the 6th and 7th grades of the East Lansing schools, and organized also two classes in wood work for the boys.

domestic art and proved to be most valuable to all concerned. The new courses in this department, color and design, textiles, and the advanced wood work are increasingly popular.

The custom inaugurated last year by a trip of the Senior women to Saginaw, to visit the manual training schools of the city, was continued this year by a tour of inspection to Battle Creek. Here not only were the schools visited, but "Postumville" and the various departments of the Sanitarium also, making it a most satisfactory day.

We regret to report the resignations of Misses Mac Donald, Long and Hopson at the end of the year. These teachers have all been efficient workers, and we wish them much success in the future.

Respectfully submitted,
MAUDE GILCHRIST,
Dean of Home Economics.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF BOTANY.

President J. L. Snyder:

I herewith submit my last report, at the close of forty years of continuous service at this College, June 30, 1910.

A summary of the classes instructed.

Class.	Subject.	Term.	Hours per week.	Students enrolled.
Graduates	Trees and shrubs	Spring	5	1
Seniors and Juniors	Plant physiology	Fall	8	11
Seniors and Juniors	Weeds	Fall	5	20
Seniors and Juniors	Grasses	Spring	4.5	9
eniors and Juniors	Plant physiology	Spring	8	20
Seniors and Juniors	Wood histology	Winter	8	9
Juniors in Agric. Forestry	Plant pathology	Fall	9	32
Junior women	Trees and shrubs	Spring	5	10
Junior men	Trees and shrubs	Spring	5	15
Junior Forestry	Trees and shrubs	Spring	5	21
Sophomore Agric. and Forestry	Ecology	Spring	2	89
Sophomore women	Ecology	Spring	2	42
Sophomore women	Plant histology	Winter	5	46
Sophomore men	Plant histology	Winter	8	46
Freshmen women	Beginning	Fall	4	109
Freshmen men	Beginning	Fall	4	178
Freshmen women	Fruits and seeds	Winter	4.5	75
Freshmen men	Fruits and seeds	Winter	4.5	153
Freshmen women	Taxonomy	Spring	4	68
Freshmen men	Taxonomy	Spring	7.5	142
Short course men	Fruit	Winter	5	30
Total			4	1,170

THE HERBARIUM.

As the room available for herbarium specimens is just about filled, little attention has been given the past year to gathering more plants. Below is the list.

Seed Plants, Ferns and their Allies:

Purchased of C. F. Baker, foreign economic seed plants	140
Home collection	23

FUNGI.

E. Bartholomew, Fungi Columbiana, Centuries 30, 31, 32	300

ALGAE.

F. S. Collins, Fascicles XXXII, XXXIII	100
Total additions for the year	563

GENERAL SUMMARY OF THE PLANTS IN THE HERBARIUM.

Seed Plants and their Allies	82,069
Mosses and Liverworts	2,010
Lichens	1,186
Fungi	17,953
Algae	2,470
Grand Total	105,688

THE BOTANICAL MUSEUM.

Neatly done up and placed in one of our rooms on top of a book-case is a package bearing the above inscription. The package contains the record of a museum burned in 1890—twenty years ago. In the attic and packed away in boxes and in the basement, are cords of interesting specimens, which, if placed on exhibition with additional materials would serve to interest not only our students, but visitors who seek entertainment and instruction. I have many times thought of carting them to the dump heap in despair, but they are still here in the way.

THE BOTANIC GARDEN.

Much has been said from year to year and the notes below contain some paragraphs. The labor of keeping the plants neatly labelled is no light task. From observation, I learn that very few visitors ever stop to read a label, yet if some plants are not labelled for a few weeks, some complaints are heard. I have previously referred to my plan of having every plant numbered as well as named. The number is punched on a piece of zinc about six inches long, and the numbers are written in a book consecutively and opposite each number is the name of the plant. Each zinc with its number is crowded down into the soil full length next to the stake on which is written the name. This system

trouble and saves danger from mistakes. Last fall every plant label was taken up and carried to the laboratory where it was cleaned up and repainted. In the mean time a plain stake was placed next each zinc label to mark its location. The main catalog of plants is kept by families, each plant on one or more manilla cards about 5x6 inches. Opposite each name is written its number above referred to. For ease of management, the present acreage may better contain only one-third of the present number of species and these may be the easiest managed and in most cases those most beautiful in larger patches. To this spot, I bid good-bye, good-bye; may it fall into good hands.

By actual count on July 2, the botanic garden contained 2,099 species and varieties. The garden is now thirty-three years old.

THE ARBORETUM.

For a full account of this interesting area of about one and one-fourth acres, where planting of trees was begun in 1875, the reader is referred to my last report, page 47.

ANSWERING QUESTIONS.

Although not an officer nor an employee of the Experiment Station, for the past six years I have answered about 5,000 questions concerning grasses, weeds, trees, fungi and many of a miscellaneous and more general character. This includes the oversight of the examination or testing of about 650 lots of seeds of clovers, grasses, etc., collected or sent here by farmers and merchants. Work of the above description coupled with the oversight of the garden, except a few days at a time, has kept me at my post at the College, continuously for many years past; with less interruption than any man at the College excepting Mr. L. F. Newell who has served for fifteen years instead of forty.

PERSONAL.

As on the 9th of next July, it will be forty years since I became a teacher at this College, possibly it may be in order to mention some of the leading events in which I was the chief factor.

1870. Wrote *The Western Rural* in defense of M. A. C.; placed zinc labels on many trees of the campus; wrote ten articles for the *Prairie Farmer* concerning the Michigan Agricultural College; wrote the *Country Gentlemen* and the *Adrian Times* of M. A. C. as a successful agricultural College.

1871-2. Taught a little of most everything; began taking the work in horticulture as well as continuing the botany.

1873. Started a grass garden and a weed garden which was highly commended by President of the State Board as one of the best things ever done at the College; chairman of the Orchard Committee of the State Pomological Society to visit the best orchards and places in the State and report; began constructing the drives and planted a large number of trees about the campus; wrote the *Adrian Times* regarding the success of M. A. C.

1874. Built new green houses; described more than one hundred

varieties of apples by their flowers, noticed as new and valuable by the State Horticultural Society.

1875. Collected timber to exhibit at the Centennial Exposition; wrote up prominent grasses and other forage plants; continued experimenting, lecturing and writing about forestry; and for the State Pomological Society; wrote of the Forests of Michigan.

1876. Collection of timber, grasses and potatoes exhibited at the Centennial were awarded diplomas.

1877. Reported as chairman of the second Orchard Committee of the State Pomological Society; finished planting an arboretum of 150 species; began testing seeds that were in the market, especially those left at groceries to sell, to find many that were of very low vitality; tested seeds of red clover harvested in a very wet season; prepared the first edition of a Guide to the trees and shrubs of the College campus; began a botanic garden.

1878. Completed experiments in crossing wax beans with foreign stock to find the advantage of such crossing to be in yield of dry seeds, as 236 exceeds 100 in favor of such crossing, highly commended by Dr. Gray, the noted botanist, who wrote, "The experiments are very neat and to the purpose."

The Rural New Yorker reports the results of my seed testing; began testing thirteen kinds of dry posts, some set "top end" down, some set "right end" up, to find there was practically no difference in durability; wrestled strenuously with student labor for pay with insufficient foremen; in *American Naturalist* article on *How Thistles Spin.*

1879. In report of American Pomological Society described varieties of apples by their flowers, previously said to be impossible; buried in bottles filled with damp sand 20 sets of 20 kinds of seeds of weeds 50 each to test a set of each five years for vitality; began experimenting and continued for eight years to learn the need of bumble bees in affecting the yield of seeds of red clover; bought about thirty compound microscopes for students' use; began to serve for five years as lecturer of Capital Grange and three years as Master of Ingham County Pomona Grange; wrote for the *Rural New Yorker,* "Michigan Agricultural College: Her Professors and Students in the Class-room, Field and Garden;" introduced a plan of placing a compound microscope in the hands of each student in the study of plant histology.

This closes the mention of the first decade of my work at M. A. C. in addition to the regular routine of teaching and overseeing labor.

1880. In the spring moved into the first botanical laboratory; lectured at the State Teachers' Association on the *New Botany.* This text afterwards passed through the third edition as a separate pamphlet. Note the following: In 1891, Swan Sonnenschein & Co., London, published a work entitled *The Best Books,* in which five were named on teaching botany, two were German, one English, two American. One of these was *The New Botany,* a lecture on teaching by W. J. Beal.

The green houses contained about 1,500 species and varieties of plants mostly of especial value to students in botany. We have the oldest grass and weed garden in American and furnished many living specimens to aid five Agricultural Colleges, Harvard University, later the State Nor-

mal College and the State University; lecture on Agricultural Education before the Connecticut State Board of Agriculture.

During the past ten years, I wrote articles and timely notes for the *Michigan Farmer, Prairie Farmer, Scientific Farmer, Farmers' Review, Country Gentlemen, New York Tribune, Gardner's Monthly, Land and Home, Post and Tribune, Free Press, American Annual of Rural Affairs, Rural New Yorker, American Agriculturalist and journals in England, Nature, Garden, Gardner's Chronicle.*

1881. Elected Secretary of the American Pomological Society serving for four years. This year I was one of the two men to found the Society for the Promotion of Agricultural Science for which members were sellected from the United States and Canada; W. J. Beal the first President; President of the biological section of the A. A. A. S. giving an address entitled: "Agriculture, its needs and opportunities," and pronounced by the *Rural New Yorker* the best thing I ever wrote.

1882. Two pages of the report of the Board of Agriculture contained a list of questions asked by mail; these came from twenty different states.

Dr. J. T. Rottnock, a graduate of Harvard, in the *Botanical Gazette* for April 1888 wrote, "The laboratories of Harvard, Michigan (two) and Iowa have taken the initiative in introducing needed reforms and already a most promising crop of fruit is the result;" tested a lot of seeds procured indirectly from twenty-three seedsmen, the results of which occupy sixteen full pages of the *Report of the State Board of Agriculture;* experiments made on crossing corn with foreign stock showing in one case an increased yield of 51 per cent, in another case 21 per cent; my report contained a map and the list of plants in the botanic garden.

1883. As I had only recently been relieved from teaching horticulture and managing the horticultural department, questions were still numerous,—sometimes ten in one day; lectured at the annual meeting of the Illinois Horticultural Society; also the State Agricultural and the State Horticultural Societies of Wisconsin; served as President of the State Teachers' Association; tested many more seeds sold by seedsmen.

1884. Exhibited a forestry collection at the Exposition held in New Orleans; working all spare time on Volume one of *Grasses of North America.*

1885. Much time spent in the herbarium, also in collecting, preparing and arranging specimens in the botanical museum; when it was not uncommon to hear visitors remark something like the following, "This suits me the best of any place at the College."

1886. A meeting of the State Horticultural Society was held in Lansing. I quote from the Secretary's (C. W. Garfield) report of this year: "The time having arrived for the special exercises of the evening, one of the most pleasant hours of the convention was now occupied by members of Dr. W. J. Beal's class in botany. Seventeen young ladies and gentlemen, fresh from original work in the botanical laboratory, gave three minute talks to the assembled horticulturists upon topics which they had been studying by the aid of the microscope.

"The work these young people are doing at the Agricultural College was not attempted in any of our colleges twelve years ago. They are

taught to be independent of what has been printed, and are placed at once in the field of original investigation. The glimpse they gave us of their methods spoke well for the work Dr. Beal is doing.

"The subjects of the talks given us were as follows:

1. Structure of a leaf.
2. The mouths of a leaf.
3. Young hairs of a leaf.
4. Sting of a nettle.
5. Protoplasm in motion.
6. Palisade cells in a leaf.
7. Starch of common and wild Arizona potatoes compared.
8. The frame work in a leaf.
9. Fibers of cotton, flax and wood compared.
10. Why nuts are hard.
11. Tough and brittle white ash as seen magnified.
12. Structure of a grain of wheat.
13. Pollen and its growth.
14. Quince-rust.
15. Corn smut.
16. A study of common mould.
17. Effects of severe cold or heat on cells and their contents.

"The drawings made by the students and employed in their explanations were admirably executed, and on the whole the entire exercise was as interesting as anything ever presented to the Society. The students were questioned upon the topics they elaborated by the horticulturists present and the answers were prompt and clear."

The full text of this exercise with a copy of the drawings appears in the Report of the Secretary of the State Horticultural Society for 1886.

Made a thorough examination of six samples of lawn grass seeds,—mixtures sold by seedsmen and each lot tested in plots, to note the appearance of such patches of lawn. Bulletin number 16 was prepared and consisted chiefly in answers made to questions concerning grasses; note what others say of the department of botany and forestry. The Botanical Gazette gives some account of the botanical laboratories of twelve prominent "Institutions of learning, including the Michigan Agricultural College."

"The botanical department of Michigan Agricultural College rejoices in the most imposing building especially for botanical institutions in the country. The upper stories contain the botanical museum, very instructively arranged, (This is the only botanical museum referred to in the article quoted.) "This laboratory has long been noted for the observant and independent work of its students."

"The point in which Dr. Beal excels as an instructor is that of leading his students to observe and think for themselves. He believes in studying nature, rather than books, and his efforts are always directed towards developing the mind of the student by inducing habits of careful observation."

"Dr. Beal sets all his students to work and the results of their observations form no mean contribution to botanical science."

1887. Improving the course of study; giving much attention to the

flora of the state; working hard on Volume 2 of Grasses of North America. Volume 1 of Grasses was printed and very well received. It contains 407 pages and here notice some of the opinions concerning its value:

"There is nothing half so good of the kind in the English language. You have taken room to cover the ground thoroughly and well." Prof. F. L. Scribner, of U. S. Department of Agriculture.

"I cannot express to you how glad I am to see this book which fills such a want in our literature. I shall recommend it whenever I can to our young farmers and others. No one else in America could have given us a book on grasses equal to this by Prof. Beal." W. A. Henry, Prof. of Agriculture, Wisconsin University.

"Two books have appeared within a few days of each other and are by far the most noteworthy contributions to agricultural literature that have been made of late years. One of these is 'Grasses of North America,'" Dr. H. P. Armby, Prof. in the University, Madison, Wisconsin in the Western Farmer.

"It contains a vast deal of information. One of the valuable features is the consideration it gives to all the different sections of the United States and the rest of the World. * * This you have come nearest to doing of all works now extant." Dr. E. W. Hilgard, Prof. of Chemistry, University of California.

Read the following:

In 1891 Swan Sonnenschein & Co., London, England, published a work entitled *The best Books* in which nine works were named on Pasture and Grass Lands, Grazing, one for India, four for England, one for North America, Vol. 1 *Grasses of North America*, by W. J. Beal.

1888. The Hatch Experiment Station began this year, the writer giving one-third of his time to such work; more lectures on grasses; especially during the long vacation, all the time possible was given to work experimenting in the north central portions of five counties in the Southern Peninsula; in May, accompanied by Prof. L. H. Bailey, C. F. Wheeler, two seniors, we made a trip for two weeks, passing from Harrisville in Alcona county to Frankfort in Benzie county. The object was to study the conditions for Agriculture, horticulture and forestry. I was a member of the State Forestry Commission, making a report of nearly 100 pages in the report of the State Board of Agriculture. In January a Forestry Convention with much enthusiasm was held in Grand Rapids planned by the Commission, Hon. C. W. Garfield and Dr. W. J. Beal. The report covered 71 pages.

Began and continued three years to experiment in growing grasses and other forage plants on thin sandy land in five counties viz.: Au Sable, in Iosco county, Grayling in Crawford county, Harrison in Clare county; Baldwin in Lake county and Walton in Traverse county; growing forest trees at Grayling and Au Sable.

1889. These are busy years for the department of botany in making experiments and keeping up the garden, herbarium, paying three or four visits each year to five northern counties to look after experiments with grasses and tree planting.

This closes the mention of the leading items of the second decade at M. A. C.

1890. The herbarium was increased during the year by more than

10,000 plants. On March 23, the botanical laboratory was destroyed by fire, the apparatus, herbarium and a portion of the museum were saved. The building had stood for about ten years. There was no let up in the various kinds of work in botany and forestry. The experiments at the north have been continued; began selecting different types of several species of grasses.

1891. For several reasons, at my urgent request, the Board of Agriculture relieved me from longer serving as one of the staff of the Experiment Station.

Tested at the College 162 grasses and other forage plants; prepared a bulletin No. 62 each containing samples and an account of the seeds of our six worst weeds; also bulletin No. 77 entitled "Comparing the yield of old meadow with those recently seeded"; the average yield for two years on stiff clay land showed that a mixture of eight sorts yielded nearly 51% more than the heaviest one of the eight grown by itself.

1892. Additions to the herbarium 7,357 specimens; a history of the botanical department was published in the report of the Secretary of the State Board of Agriculture; a long program was carried out in connection with laying the corner stone of the 2nd Botanical Laboratory; with the assistance of C. F. Wheeler, I prepared a Flora of Michigan, containing also much other printed matter.

1893. Moved from temporary quarters in the first Agricultural Laboratory to the second Botanical Laboratory of this College; prepared by request for the *Engineering Magazine* an article on Forestry; and another for the *Grand Rapids Democrat* on Our Forest Fortune; exhibited at the World's Fair in Chicago, 28 bundles of grasses, 38 full length specimens flat on paper, 207 boxes of seeds of grasses and other forage plants; 9 volumes of laboratory work of students; interesting drawings by students; roots of Indian corn as washed from soil (diploma for this); samples of crude drugs of Michigan; herbarium specimens showing color of leaves in autumn, native shrubs noted for their flowers; some distinguished for beautiful fruit, some distinguished for color of bark, native climbing plants, bronze evergreens, native marsh plants good to cultivate, aquatic plants good to cultivate, native ferns good to cultivate, plants indicating fertile soil, plants indicating sterile soil; list of wild fruits and nuts.

1894. The State Academy of Science was organized with W. J. Beal the first president. The first report 1894-1899 inclusive, contained the following:

Some notes on the Michigan Coat of Arms; the needs of Michigan Forests; nature Study in the common schools; (eight bulletins); trees as dwelling places for animals; a study of our native elms and poplars in winter.

Ginn & Co. published during this year, *Seed Dispersal* prepared by W. J. Beal.

1895. Additions to the herbarium 8,812 specimens. A good "write up" of the botanic garden was printed in *Garden and Forest;* an excellent map of the garden with the list of 1,335 species of plants was printed in the report of the Board of Agriculture; as usual presented papers at meeting of S. P. A. S.; A. A. A. S.; State Grange; State Acad-

emy Science, State Horticultural Society and several Farmers' Institutes; prepared an abstract entitled *Points on Weeds* distributed at numerous Institutes.

1896. Spent four weeks of the "winter vacation" so called, attending Farmers' Institutes in twenty different counties of the State; M. A. C. Record begun, for which I began furnishing items in great numbers, continuing up to June 1910; published the first edition of *A Glossary of Botanical Terms* for use of our students; Henry Holt & Co. publish Vol. 2 of Beal's *Grasses of North America* 707 pages; planted up the river about 2 acres to white pine and on the west line of the farm, a double row of white pines from the river south to the back end of the farm.

1897. In my report I speak of fairy rings among seed plants; full record of botanic garden, and weed garden; in M. A. C. Record I furnish, "He worked his way through College"; "A good education pays"; "Why take a course in College? Fifteen objections answered."

1898. Published an addition to the *Michigan Flora* of 236 species of seed plants; also a list of fungi belonging to the Hymenomycetes, gastromycetes, myomycetes.

1899. Adding much to the botanic garden and herbarium; begin to serve as path master for five years to improve the roads of the neighborhood; write hints on Grasses, Northrup, King & Co., Minneapolis, Minn.

This closes the notes of selections from the third decade.

1900. Much time spent in the preparation of a general catalogue of 267 pages of the students of this College; something every week for the *M. A. C. Record* and *Michigan Farmer;* from year to year the work of answering questions by mail increases; all the details of work in collecting and planting, making labels and general management of the Botanic garden falls on me, except one man who knows no botany and with some labor by students. Write for *Michigan Farmer*: "M. A. C. as a summer resort"; "Anthracnose and bacteriosis prevalent on beans, a remedy."

1901. Gave an address on teaching botany at a meeting of the Science teachers of New York, held at Rochester; at a meeting of the State Academy of Science read a paper on the "Relation of Botany to Agriculture," in Michigan Farmer, "How to manage a Farm woodlot"; prepared a list of the trees and shrubs naming the spot where one or more specimens could be found on the Campus. This covers 22 pages of the Report of the State Board.

1902. Every year additions have been made to the herbarium till now there are 81,254 specimens. At a session of the Michigan Academy of Science, I read a paper on *What shall the Michigan Farmer grow for Fence Posts and Telegraph Poles.* For the M. A. C. Record, I wrote *"Why attend College?" "Two M. A. C. Boys go to the Senate;" "The trees at M. A. C." "Education multiplies the chances for success."*

1903. Prepare a new edition of the Michigan Flora, much changed and improved, consisting of 147 pages; printed the next year in the Report of the State Academy of Science, "The scope of the Agricultural Section of the State Academy of Science"; "Helps to the High School teachers who teach Natural Science"; "How I know some of our trees in winter."

1904. Lecture on teaching Agriculture at a meeting of the State Grange; prepared two popular bulletins on *Grasses and Other Forage Crops* for the use of subordinate granges; prepared a new edition of a Glossary of Botanical terms for use of our students; urged the need of an addition to the Botanical Laboratory, from year to year without securing any result.

1905. Sent a limited collection to the Louisiana Purchase Exposition at St. Louis; learned much about the management of a botanic garden, of two acres costing about 900 dollars per year by far the cheapest garden of its size and quality of any within my acquaintance; giving much study to the botanic garden to make it larger; paths now all covered by living grass, seeded by inoculation; much filling by dirt to raise the surface one to five feet up to the high water mark; using dirt from the tunnel through which passes the heat and electric wires from boiler house to all the main buildings; plants of several families shifted into new places; a lengthy report concerning the garden was made this year; keep up the collection of grasses, especially those of economic importance, such as ten sorts of orchard grass, twelve of timothy; have one plat of tender-leaved orchard grass especially desirable and for several years have been experimenting to obtain a race of timothy that should be vigorous and at the same time early to flower at time of red clover; note the plants which attract most attention in different months of the growing season; quote expressions by visitors regarding the garden, showing their appreciation of these two acres in the ravine:

"Oh, the lovely pink water-lilies!" "Isn't this old log cabin cunning?" "I think this is just the loveliest place." "No use talking, this is a very interesting place." "Just beautiful." "This is the prettiest place I ever saw." "Here is another plant I don't know." "This garden is the dearest little spot." "It is certainly lovely." "What a beautiful place!" "These grass walks are so nice to walk on!" "Oh, here are some pink water lilies, the first I ever saw. How sweet!" "How fine and large these white water lilies are!" (referring to the large ones from Europe.) "One can find everything in this garden!" "See the grass walks!" "My, but this is a swell place!" "Oh, what a pretty poppy bed!" "Aren't these grass walks fine?" "How clean and trim everything is kept here!" "The little log cabin in the garden!" "I would like to live here." "Ain't them nice!" "How lovely these ferns are!" "If you want to see a pretty place just go down into the botanic gardens." "They ought to be prosecuted for letting these thistles go to seed." (supposing they were Canada thistles, which they were not.) "I wonder if there is anything they haven't got here." "Look at the pond lilies! Here are some pink ones!" "The pretty poppies!" "Them labels are jaw-breakers, ain't they?" "The little log cabin!" "What a delightful place this is!" "Just see these old-fashioned daisies!" "Them pink lilies are just like wax." "I wish I could spend a week here." Visitor to gardener: "What are you making?" Gardener: "A rustic bridge." Visitor: "I guess it will be rusty, all right." "Oh, Dr. Beal, I have found you at last! I want to thank you for planting this beautiful garden." "I have never seen anything like it either in the United States or Europe." "I can truly say that I have been struck speechless at the sight of plants so foreign to this country." "Isn't this a lovely view?" "I believe these

benches were placed right where we could get the best view of the garden." "I didn't know that there were so many kinds of timothy and orchard grass." "Is that the way you start these grass walks?" I never thought of that before." (Referring to small bits of sod scattered over the place and then rammed down.) "This little garden looks as if it would keep one man busy most of the time." Come around this way and see the ferns, they are lovely." "Look here, they are raising mulleins! I wonder if that is educational?" "My, those morning glories are fine." "I wish I could pick some seeds." "Say mister, is this bridge safe?"

An artesian well long needed was placed in the garden this year.

1906. Continue raising the soil in the botanic garden; visit four botanic gardens to see what other plants are desirable and plan for exchanging; added this year 12,721 plants to the herbarium which has now passed the 100,000 mark, and very nearly fills all the cases that occupy all the available space in the herbarium; collections are especially prominent in plants of economic importance, by far the best collection of Michigan plants in existance.

1907. The botanic garden as well as the herbarium contains large numbers of plants of economic importance; many grasses, clovers, wild potatoes, beans, peas, mints, wheat, weeds, ornamental herbs and shrubs; I lecture at the annual meeting of Ginseng Growers on the Diseases of Ginseng; began a series of 20 illustrated articles on weeds for the *Michigan Farmer;* spoke at the semi-centennial of this College on *The College in 1870.*

1908. After raising the soil in a good portion of the garden, the banks of the brook became too high and the space too wide for convenience, it occupying too much room; 250 feet of the brook now passes through a tunnel which is covered by good soil furnishing considerable room for more plants; botanical laboratory now and for eight years much crowded and inconvenient.

1909. The class roll this year numbered 1,037 names of students; where we had four rooms for six teachers, for two years, often carrying microscopes daily from one building to another and refusing students in plant physiology for want of a suitable room, although we taught two small classes each year. We were crowded to inconvenience, suffocation and disorder, detrimental to the proper care of apparatus and for performing first rate work; the old head professor doing more than any one else and still certain other classes try hard to avoid joining work under instructors.

1910. The class roll this year numbers 1,170 over 400 during the spring term; bulletin No. 260 of the Experiment Station by W. J. Beal published, containing 215 fine cuts of seeds of weeds; the botanic garden consists of two and one-tenth acres and contains 2,099 species and varieties mostly grouped by families and is in as good condition as it ever was; addition to the botanic laboratory was secured, but not in time for me to use it a single term with its equipment. The papers and alumni say considerable about the man who stayed forty years,—many very nice things, in many cases reports appear to me too highly drawn.

This closes the mention of some of my work during the fourth decade.

PERSONAL CONTINUED.

I enumerate below the papers, journals, and reports to which I have contributed during the past forty years with an approximate number for each. I am sure the list is incomplete, especially is this true of the M. A. C. Record, Michigan Farmer, and State Republican.

1.	The State Review	1
2.	Report of Superintendent of Public Instruction	8
3.	State Affairs	1
4.	Proceedings of the Society for the Promotion of Agricultural Science	34
5.	Michigan Farmers' Institutes	10
6.	Michigan Board of Agriculture	118
7.	Michigan and its Resources	2
8.	Popular Science Monthly	1
9.	Asa Gray Bulletin	1
10.	Torrea	1
11.	Scientific American, Supplement	1
12.	The Scientific Farmer	6
13.	American Journal of Science and Arts	3
14.	The Michigan Horticulturist	8
15.	The Independent	1
16.	New York Science Teachers' Association	1
17.	American Monthly Microscopic Journal	1
18.	Transactions of the Illinois Horticultural Society	1
19.	Agricultural Science	3
20.	School Science	1
21.	Bulletin of the Torrey Botanical Club	5
22.	The American Garden	1
23.	The Engineering Magazine	1
24.	American Gardening	1
25.	The Family Circle	1
26.	The Cultivator and Country Gentlemen	1
27.	Western Rural	1
28.	Times and Expositor	2
29.	Ypsilanti School	1
30.	The Little Corporal	1
31.	New York Tribune	10
32.	State Republican	6 and more
33.	Chicago Times	7
34.	Proceedings of the American Pomological Society	6
35.	Report of the Directors of the State Forestry of Mich	15
36.	Cyclopedia of American Horticulture	1
37.	Report of the Connecticut Board of Agriculture	1
38.	Grasses of North America	2
39.	Seed Dispersal	1
40.	Mich. Agricultural College, Gen'l Cat. of Officers and students	1
41.	Grand Rapids Democrat	1
42.	Journal of Applied Microscopy and Laboratory Methods	2
43.	L. B. Case's Botanical Index	1

44.	Rhodora	4
45.	The Naturalist Teacher	1
46.	The American Naturalist	29
47.	The M. A. C. Record	104 and lots more
48.	The Prairie Farmer	81
49.	Proceedings American Assn. for the Advancement of Science.	46
50.	American Park and Outdoor Art Association	2
51.	Gleanings in Bee Culture	56
52.	Garden and Forest	20
53.	The Advertiser, Union Springs, N. Y.	45
54.	The Rural New Yorker	70
55.	The Hudson Gazette	9
56.	The College Speculum	32
57.	Elementary Science Bulletins	9
58.	Botanical Gazette	36
59.	The Michigan Farmer	220 and more
60.	Transactions Mich. Horticultural (Pomological) Society	73
61.	The New Botany	1
62.	Michigan Moderator	26
63.	State Forest Commission (see page 43)	
64.	The Plant World	3
65.	Farm Home Journal	45
66.	The Philadelphia Press	8
67.	Illinois Teacher	4
68.	Grange Visitor	35
69.	Science	19
70.	M. A. C. Bulletin	1
71.	Roads and Forests	8
72.	Proceedings of Ginseng Growers	3
	Total	1,286

Certainly not a large number. From the above I have selected a few topics which I think have the greatest merit:

New Botany.
Grasses, Vol. I.
Seed Dispersal.
Vitality of Seeds.
Elementary Science Bulletins.
Succession of Jackpines or Succession of Forests.
Experiments on Advantages of a mixture of grasses.
Planting Trees on Sands.
How Thistles Spin.
Crossing with Foreign Stock.
What to Grow for Poles and Posts.
Sensitive stigmas an Aid to Cross Fertilization of Flowers.
Describing Apples by Flowers.
Inequilateral Leaves.
Phyllotaxis of Cones.
The Twining of the Stems of Hedge Bindweed.

Distinguishing species of Populus and Juglans by budscars and naked branches.

Lima Beans in Germination.

Bulliform Cells of Grasses and Sedges Compared.

Prophyllae of Graminea.

Sugar Maples of Central Michigan.

Observation of Root Hairs.

Crossing Beans and Corn with Foreign Stock.

Gas Plant Shoots Seeds.

Fairy Rings in the Botanic Garden Indicating the Need of Rotation of Plants.

The Fruiting of Mesocarpus (Pleurocarpus).

Contrasting the good points of grasses with the weak points.

BOOKS.

New Botany, The	1880	p. 27
Grasses of North America, Vol. I	1887	pp. XIV 457
Vol. II	1896	pp. VIII 706
Seed Dispersal		p. 90
General Catalogue of M. A. C.	1898	p. 267
Glossary of Botanical Terms, 4th Edition	1909	p. 58

At different times I have prepared four to six articles or more on Grasses and other forage plants for the *Philadelphia Press, Rural New Yorker, Land and Home, Michigan Farmer.*

I have been in full active work here longer than any one else,—my former honored colleague, Dr. R. C. Kedzie, having come next. For a long time three of us pulled together and pulled apart, Kedzie, Cook and Beal. We were a restless triumvirate, each ambitious for his department and what he believed for the good of the College. It annoyed us to see the blunders that others made. Often things went too slow to suit us. We chaffed and grumbled and sometimes made the fire fly. We were each critisized and received hard knocks from those high in authority.

To notice the many kind attentions of everybody at the close of my service one might almost be led to believe that I have done some great things. It is gratifying to be thus treated, but you are not familiar with the hosts of mistakes I made, especially in the first ten or twenty years of my service at this College. Most of the witnesses have died and are not present. In 1872, I considered myself to be 20% of this College, since which time I have from year to year, as the College has grown, gradually diminished in relative importance till the past year when I have been perhaps 1% or less of the whole concern. In my time here, I have lived with six College presidents, outlived four who have gone to their long home; one has retired for another pursuit and I have done fully my share toward worrying the sixth man who seems to be good yet for many conquests.—President Snyder. I have been in the faculty with ten professors of agriculture, and since the first one did not begin till 1865, there were ten professors during 45 years, averaging a period as you see of four and one-half years each, not to include the thirty-eight

years that the present incumbrant Dean Robert Shaw is liable to continue.

I have lived to see ten professors of horticulture, one of whom spent ten years trying to fill the chair and to see him I had to resort to the use of a looking glass. There is no doubt that the growth of this college has been retarded fully fifteen years by a number of injudicious appointments and by frequent changes of members of the faculty.

I think I care more for the success of this College than anybody else. Why shouldn't I? I have written and spoken much in defense of the College and its management and have put the greater part of my active life into it.

I came here when it was only thirteen years old, having seen all her 6,000 or 7,000 students excepting perhaps 20 in number.

I have been a pioneer teacher in a pioneer agricultural college, an excellent place in which to do lots of hard work with little reward and many curses. I think I have done fully my share of dead work.

During forty years, botany has progressed wonderfully, I have helped to clear the way, leaving the work to be continued by others who have been better trained in modern methods. I began with Williams Hall in 1870 and you have observed that both of us are showing the marks of time and getting out of repair.

It was my good fortune to secure healthy, vigorous parents who were frugal, industrious, temperate and religious, truly a priceless inheritance.

For a man of my age, I seem to be pretty well preserved, which may be attributed to a good start as a youngster, to eating light and of few varieties, to using no tea, coffee, tobacco or intoxicants, to the fact that I am a good sleeper and have had plenty of young associates who have been hopeful and wide awake.

Contrary to the usual experience, my life seems to me a long one; the last two-thirds of it the happiest days instead of the days of my youth. I still live mostly in the present and not in the past. I have never had many very intimate associates.

Am I not tired of botany and wish it all in the bottom of the ocean? No! because it is often renewed and always presents some new phases, but if all this time I had been teaching mathematics, history or English, it would have been far different.

Like a child eager to open a package to see what it contained, a restless inquisitiveness to know things has always proded me on. I still have it. I love nature, rarely ever passing a tree or shrub without turning around to see the other side of it.

In teaching I enjoy giving it a practical trend, whenever possible; I have tried constantly to teach students to be self reliant, independent observers. I appreciate in the highest degree a statement like the following made a few weeks ago by a former student who spent one year at this College in 1874 and has since been teaching and farming. He said. "I remember well that you gave me a pea vine and kept me studying it for three days before telling me anything. I now consider it the most valuable lesson I ever learned from any one."

The library has only a partial set of the reports of the A. A. A. S. I have placed in the hands of the librarian forty-two volumes which will fill the gaps and more.

I give to the college, an herbarium that came to me many years ago. The plants were collected and mounted in 1845-1850 and earlier, by an invalid uncle, George F. Comstock. It consists of five hundred ninety-two (592) well preserved specimens, mounted on sheets bound in five books. Many of them were collected in Lenawee County, Michigan, some in Farmington, Ontario County and vicinity in the State of New York.

This is of special interest for its age as it antedates the collection made by Dr. Dennis Cooley by several years.

As you already know, I have been connected with the Experiment Station, at first about four years, and more recently one year. Such bulletins as came to me from the different states, will be left in the cases in the botanical laboratory. During forty years, I have received large numbers of reports, and bulletins from the U. S. Department of Agriculture and from various sources, American and foreign, and great quantities of separates, nearly all of which will be left on the shelves. The pamphlets are classified and arranged alphabetically in covers, making fifty or sixty running feet.

From time to time about fifty text books more or less treating of various topics botanical, horticultural, forestal and agricultural have been sent me for an opinion. The majority of these were passed into the college library, some have been lent and not returned and most of the others will be left in the botanical laboratory.

There is also a collection of photographs of lumbering operations in Michigan, far the most complete extant, much of which could not now be duplicated. We have negatives and slides of some of these.

Sincerely,

W. J. BEAL,
Professor of Botany.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF BACTERIOLOGY.

President J. L. Snyder:

Dear Sir: With the most efficient support of Dr. Rahn, who has had the immediate charge of the laboratory classes, and his assistant, Miss Farrand, there has been no cause for uneasiness. Students who have passed through the initial laboratory courses and have reached the applied portion of laboratory bacteriology successfully, fully appreciate the bearing of the instruction upon daily problems.

Miss Northrup has assisted in class work in "Bacteriology 1," and has had full charge of the course in "Hygiene of Food." Miss Northrup deserves much credit for her skill in class instruction and management.

Dr. Ward Giltner, although wholly connected with the Experiment Station, taught two classes in "Personal Hygiene" in the fall, a class of short course students during eight weeks of the winter term, the senior veterinary students for the remaining four weeks of the winter term, the seniors and freshmen during the spring term. Dr. Giltner has given

to the college a large part of his time for the past year, but this was brought about by unforeseen circumstances. It is with praise only that I recognize his able work.

Mr. C. W. Brown very satisfactorily and successfully led the short-course creamery students and cheese students through those phases of bacteriology which touch their vocations so closely. This is a most difficult task and calls for patient dealing.

In regard to the health of the institution, it may be said that measles, scarlet fever, and mumps have been lurking at its doors the entire year. Here and there a case would appear, but with the splendid isolation facilities, these diseases have been shut out without epidemic significance.

The close relation of college and city in health matters renders the situation peculiarly delicate. The tact and skill of the City Health Officer, Dr. Oscar Bruegel, has rendered the task of control simple and effective.

Those matters relating to the manufacture of "Hog Cholera Serum," "Nitro-culture," "Vinegar-culture," "Lactic-cultures," and our attitude toward tuberculosis will be embodied in our Experiment Station report, inasmuch as these subjects are strictly scientific in large part, and are associated closely with our investigations.

Very respectfully submitted,
CHARLES E. MARSHALL,
Professor of Bacteriology.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF CHEMISTRY.

To the President:

The schedule of students and studies below given when compared with the schedule given in my last report shows that the amount of instructional work required to be done in the department has increased ten per cent over that of the preceding year.

Schedule of studies.

Fall term, 1909.	Number students.
General Chemistry:	
Engineering (freshmen)	182
Agricultural and Forestry (freshmen)	172
Women (sophomore)	57
Organic Chemistry:	
Men (sophomores)	98
Women (special)	4
Total	513

Winter term, 1910.	Number students.
Mineralogy (freshmen)	150
Qual. Anal., men (freshmen)	158
Qual. Anal., women (sophomore)	52
Agricultural Chemistry (juniors)	46
Forestry Chemistry (seniors)	14
Dairy Chemistry (seniors)	16
Total	426

Spring term, 1910.	Number students.
Engineering Chemistry (freshmen)	133
Organic Chemistry, women (sophomore)	40
Quantitative Analysis (seniors)	12
Domestic Science Chemistry (seniors)	13
Animal Nutrition (seniors)	18
Total	216

In addition to the above Prof. Reed gave a course of 20 lectures on elementary and applied chemistry to 83 special short course men during the winter term.

During the winter term I gave a course in the chemistry of wood and related products to 14 Forestry course seniors who elected it. This is the first time such a course has been offered our students, but judging from the results obtained I am led to recommend that the study be made a required subject for all forestry students.

On the completion of the new Agricultural Building, January 1, 1910. the laboratory space in the Veterinary Building previously occupied by the Experiment Station Chemist was assigned for temporary use to the department. During the winter term this supplementary laboratory was used for classes in Dairy Chemistry and Beet Sugar Technology, while in the spring term it provided an excellent place for the laboratory work of our senior agricultural students in Animal Nutrition—being so conveniently situated with respect to the animals under experiment.

As stated in my report for last year this department is in need of additional space both for laboratory and recitation purposes. Our largest lecture room has seats for but 150 persons. The class in beginning chemistry fall term, 1909, numbered 411 students. This necessitates that I repeat the same lecture three times in order to reach each member of my class. I therefore recommend and urge that the matter of an addition to the present Chemical Building be considered by the Board of Agriculture.

A wing extending eastward could be added to the south portion of the building providing for a larger lecture room accommodating 500 students and giving additional laboratory space below. This addition to the building should be ready for use by the opening of the college year in September, 1911.

During the year the following has composed the personnel of the Department:

Assistant Professors: H. S. Reed, A. J. Clark.[1]

Instructors: W. H. Parker,[2] M. L. Tower, C. M. Hargrave, H. M. Potter.

Clerk and Stenographer: Miss E. A. Goodhue.

Caretaker: George Churchill.

The hearty cooperation of each one of the above has made possible the completion of another strenuous year of college work.

FRANK S. KEDZIE,
Professor of Chemistry.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF ENTOMOLOGY.

President J. L. Snyder:

Dear Sir: Following is a brief report of the work of the department of Entomology for the year ending June 30th, 1910.

Six regular courses in entomology have been given during the year, course V. being given during all three terms. Besides this two short courses were given during the winter and one during the summer school for County Normal teachers.

At the end of the winter term Mr. M. A. Yothers left to take a position in the State College of Washington at Pullman. Miss Eugenia McDaniel, a graduate of Kansas State University, was engaged to take his place, arriving during the middle of the spring term.

The added room made available by the completion of the new Agricultural Building has made it possible to so place the collection that it is accessible and usable. It has also made it possible to take care of advanced students more satisfactorily, and has increased the efficiency of the department greatly, all of which is fully appreciated.

Respectfully submitted,
R. H. PETTIT,
Professor of Entomology.

East Lansing, June 30, 1910.

[1] Asst. Professor Clark in addition to his work in the department acts as trainer and conductor of the College Military Band.

[2] Inst. Parker in addition to his work in the department has the general care, supervision and inspection of all the college dormitories.

REPORT OF THE DEPARTMENT OF ENGLISH AND MODERN LANGUAGES.

President J. L. Snyder:

Dear Sir: I herewith submit my report as head of the department of English and Modern Languages for the college year 1909-1910.

The enrollment in the department during the year has been as follows:

	English.	German.	French.	Total.
Fall	1,564	117	49	1,730
Winter	1,542	221	35	1,798
Spring	1,180	169	20	1,369

The average enrollment per term for the year is 1,632.

The work of the year has been done by the head of the department, one assistant professor, and ten instructors. Three of the instructors, Messrs. Sloat, Williamson and Wuebker, came to us at the beginning of the year, the other members of the department having been connected with it the preceding year. The average salary paid to instructors during the year has been $785.00. The average cost of instruction per student during the year has been $6.95.

In some ways the work of the year has been more satisfactory than it has ever been before. In other ways it has been less satisfactory. With the beginning of the year it was decided that freshmen and sophomores must become, by habit, familiar with certain things which should be learned even before they enter high school, but which they do not know when they come to college. Among these essentials in an English education are terminal punctuation, capitalization, and the form of a business letter. At the beginning of the fall and winter terms it was announced to all classes that a part of the examination of each of these terms would be certain letters, and that any mistake made in the letter form would result in a condition, unless the rest of the examination was perfect. This warning was frequently repeated throughout both these terms. In spite of such opportunity to prepare for the examination there were many students who were habitually careless in these matters and who were consequently conditioned in their work at the end of the term.

In like manner it was decided that students who had presented high school work in German as part of their entrance credits should not be permitted to receive credit a second time toward a degree for the same work, and that if they entered the beginning German class they would be expected to do more work than that done by students who had never taken German before. These requirements seemed unduly stringent to some students, particularly to those who were careless in their term's work or who neglected to do the additional required work in German. So far as the improvement in the work in the department is concerned, these requirements have demonstrated their very great value. The majority of students have learned the fundamental essentials of English writing. Those who have studied German have received a definite return for the

credits received for the subject. The "conditions" that have resulted have caused complaints on the part of some students, which have unfortunately reflected somewhat upon the work of the department as a whole. This was to be expected with the establishment of new requirements. It is believed that in the future the verdict will be that these requirements are not only wise but also essential.

I suggested in my report a year ago the need of an assistant professor in German, that subject having assumed an importance which seems to justify such a position. I trust that it will be possible to bring about the adoption of this suggestion some time within the coming year.

During the winter term the department took charge of many of the first year short course men and gave them work in practical letter writing. While not one of the sixty-four men in the class wrote accurately the first letter which they were asked to write, every man, with the exception of three, wrote absolutely correct letters in the examination held at the end of the course. It is believed that these men profited very much by the two hours per week given to this work.

During the year the state oratorical contest was held at this college. Representatives from eight colleges, besides our own, spoke in the contest. With these representatives came six or seven hundred visitors. For the first time the pavilion of the Agricultural Building was used as an auditorium. There were present at the contest about seventeen hundred persons, of whom between fifteen and sixteen hundred found seats in the pavilion. Our representative in the contest was Mr. K. D. Van Wagenen.

I regret to report that after three successive victories we were defeated this year in the annual intercollegiate debate with Ypsilanti. Our representatives were Messrs. J. C. DeCamp, W. R. Walker and E. A. Close. The first named man was a senior forestry student, the second a junior engineer, and the third a freshman engineer. The statement of the judges was that our men in their argument were perhaps equal to their opponents, but that in the presentation of the argument, the delivery, they were less effective. I think that this may be readily accounted for by the fact that our men have much less time to give to that kind of work than have men in academic institutions. All in all we feel that our representatives were worthy of the fullest praise. The sophomore oration contest for the prizes offered by the English Department was won by Mr. Louis Hirshleifer, second place being won by Mr. Edwin Smith. These men are both agricultural students.

A course in agricultural journalism was presented during the spring term. This is the first time that such a course has been given in this institution, if I am correctly informed. While the results obtained are far less satisfactory than they will be another year, every member of the class felt that he had received from the two hours per week given to the work as great a return as from any other two hour course taken. An especially pleasing and profitable feature of the course was an address by Mr. I. R. Waterbury, editor of the "Michigan Farmer" and member of the State Board of Agriculture, on practical agricultural journalism.

I wish in this report to express our appreciation of Mr. Waterbury's

willingness to serve the institution in this way as well as on the State Board.

The work of the instructors with individual students through appointments outside the class hour has been carried forward more consistently and profitably than during any previous year. Every instructor realized the value that this kind of work is to the student, and willingly gave many hours to the personal suggestion and criticism which must be more helpful than class instruction. During no preceding year have the instructors so willingly coöperated in this kind of work.

The completion of the Agricultural Building made it possible for this department to secure for its use all the recitation rooms on the second and third floors of College Hall. This has relieved much of the disorder attendant upon the necessity for instructors to go from one building to another between recitations. While we are still having many recitations in both the Engineering Hall and the Agricultural Building, yet the satisfaction which comes from having six recitation rooms in one building is very great.

For the increases in salaries given to a number of instructors for the coming year, I wish to thank you and the State Board. I find that each year it is becoming more difficult to secure men of experience for the salaries paid. In fact, it is almost impossible to secure an instructor who has had experience in teaching college classes. It is unfortunate that in the past we have been a training school to take inexperienced men and to prepare them to serve other institutions after they have learned something about teaching by spending a year or two with us. A policy of regularly advancing the salaries of successful instructors and of retaining them for a number of years is one which will do much to advance the institution educationally. During the last two or three years in this department a very large majority of the freshmen and sophomores have been taught only by instructors who have had little or no college experience, and in a number of instances by instructors who have had no experience at all. Of course the kind of returns that we desire cannot be achieved under such conditions. While the day is past when a log, an inspiring teacher and a boy can make a college, yet the day is far from come when great buildings, inexperienced instructors and fifteen hundred young men and women can make the highest type of college. Should it not be the aim of this institution seldom to hire an instructor unless he has had experience in teaching either high school or college classes?

To the other members of the department I wish to express my appreciation for all their efforts during the past year. I desire also to thank you and the State Board for the appropriations made to the department and for the many courtesies received.

Yours most respectfully,

THOS. C. BLAISDELL,

Professor of English and Modern Languages.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF HISTORY AND ECONOMICS.

President J. L. Snyder:

Sir: I have the honor of submitting the following report concerning the department of History and Economics for the year of 1909-'10.

The total number of enrollments in this department during the year was 1,469, distributed as follows:

By terms, Fall 466; Winter 561; Spring 442.

By classes, Sub-Freshmen 151; Freshmen 600; Sophomores 350; Juniors 219; Seniors 159.

By subjects, History 704; Economics 563; Pol. Science 134; Sociology 68.

The total number of hours taught during the year were 2,535 divided among the three terms as follows:

Fall 754; Winter 1,044; Spring 737.

By subjects, the number of recitation hours during the year equalled in History 1,385, Economics 802, Pol. Science 238, Sociology 68.

The distribution of class work to the various members of the department together with the nature of the work performed may be gathered from the following table.

Teacher.	Term.	Subject.	Hours per week.	Students.	Number students.
Mr. Hedrick	Fall	Economics 4a	5	Jun., Sen., H. E	33
Mr. Hedrick	Fall	Economics	5	Jun., Sen., H. E	29
Mr. Hedrick	Winter	Economics 5a	5	Jun., Sen., H. E	38
Mr. Hedrick	Winter	Economics 4b	5	Soph., Eng	24
Mr. Hedrick	Winter	Economics 1a	1	Ag., Sub. Fresh	60
Mr. Hedrick	Spring	Economics 5b	5	Soph., Eng	34
Mr. Hedrick	Spring	Economics 5b	5	Soph., Eng	34
Mr. Hedrick	Spring	Economics 1b	2	Ag., Sub. Fresh	20
Mr. Ryder	Fall	History 4	5	Ag., and H. E., Jun. and Sen	42
Mr. Ryder	Fall	Pol. Science 1	5	Soph. Eng	40
Mr. Ryder	Winter	History 3	5	Ag. Freshmen	23
Mr. Ryder	Winter	History 4	5	Ag. and H. E., Jun. and Sen	16
Mr. Ryder	Winter	Pol. Science 1a	9	Ag., and H. E., Jun. and Sen	55
Mr. Ryder	Spring	Economics 6	5	Ag. and H. E., Jun. and Sen	43
Mr. Ryder	Spring	Economics 2	5	(4 div.) Soph. Ags	105
Mrs. Hendricks	Fall	History 1	3	(5 div.) Ag. Freeh	132
Mrs. Hendricks	Winter	History 1	5	(2 div.) Eng. Fresh	54
Mrs. Hendricks	Winter	History 2	5	(2 div). Ag. Fresh	49
Mrs. Hendricks	Spring	History 3	5	(2 div.) Eng. Fresh	38
Mrs. Hendricks	Spring	History 3	5	H. E. Fresh	11
Mr. Leffler	Fall	History 1	5	(5 div.) Ag. Fresh	124
Mr. Leffler	Winter	History 3	5	(3 div). Ag. Fresh	115
Mr. Leffler	Winter	History 2	5	H. E. Fresh	35
Mr. Leffler	Spring	History 3	5	(3 div.) H. E. and Eng. Fresh	63
Mr. McPherson	Fall	Pol. Sci	5	Soph. Eng	39
Mr. McPherson	Fall	Economics 1a	3	H. E. Sub. Fresh	27
Mr. McPherson	Winter	Economics 4b	5	Soph. Eng	57
Mr. McPherson	Winter	Economics 5a	5	Ag. & H. E., Jun. and Sen	33
Mr. McPherson	Spring	Economics 1b	2	Ag. Sub. Fresh	26
Mr. McPherson	Spring	Economics 7	5	Ag. and H. E., Jun. and Sen.	36
Mr. McPherson	Spring	Economics	5	Ag. and H. E., Jun. and Sen	32

The courses of study which have been presented during the past year have remained substantially identical with the ones described in previous reports and in the college catalogue. One or two minor changes are perhaps, however, worthy of notice. History 4—the constitutional History of the United States was added to the list of electives for the fall term at the beginning of the year. Owing to the fact that the course ends with the beginning of the Civil War or earlier, there has been for some time a demand from the students for a continuation of the work through another term. At the conclusion of the fall term of the past year, as an instance, the students who had just finished course 4 presented a petition to the faculty asking that an additional term of History be allowed them and the teacher of this subject is very often asked by students to use his influence in getting the subject extended to another term.

Owing to the excessive congestion of studies in the winter term of the sophomore year for the Home Economics students it was thought best by the faculty to withdraw Economics 2 from the curriculum of this division for this year. It is doubtless owing to this withdrawal and to the fact that the courses in Pedagogy were not given by this department during the past year that the number of students enrolled and the number of hours taught show a shrinkage from those of last year.

The proper presentation of economics and political science in a quasi technical school presents many special problems. The relative merits of these subjects as studies in a curriculum like ours when presented from their purely scientific aspects as compared with presenting them as applied sciences was fully discussed in the last report from this department. The variableness too, from year to year, of the subject matter in both of these studies on account of varying economic and political conditions throughout the country and the pedagogical effects of this fact was also noticed in the same place.

But in addition to such general considerations as these affecting the subjects of political science and political economy, the practical, technical presentation of economics and political science in the classroom is strongly influenced by the characteristics of a college of this sort. A choice must be rigorously made for example as to the subject matter which shall be presented in both economics and political science since the time allotment to either of these subjects in the college curriculum forbids the hope of exhaustive study of either of them. In essence the problem resolves itself into the question, shall the elements of economics and political science be presented at this place in the standardized form of the textbooks, or, shall the teacher be allowed to emphasize some portions of these subjects to the entire exclusion of others.

Either choice has many merits and many defects. If the standardized presentation is made the student has had a glimpse of the main outlines of the whole subject and it was doubtless this "reading knowledge" of the subject that he expected when he elected the course. Furthermore the student will be inconvenienced, if he has not studied all departments of a subject, should he undertake to pursue advanced work along this line at some other college.

On the other hand it cannot be said of the social sciences as of mathematics, for instance, that there is a sequence of development which must

be closely followed. Each one of them has many points of entrance from which study in all directions may be made. Again the movements of social and political life throughout the country of which these sciences are largely reflections turn up new public problems periodically and it has long since been found that the questions of the day are apt to be most interesting to the students and hence are the best for instruction purposes.

This fragmentary method of presenting economics and political science is further commended through the desirable harmony which may thereby be established between the teaching of these subjects and the teaching of the other subjects of the college. As is well known the laboratory methods of instruction are the ones which prevail here and the student almost unconsciously adapts himself to this method of study. It has been the practice of the teachers of this department therefore for some years past to select each year some "live" problem within the field of the particular social study which he was presenting and concerning which,—largely because it was a "live" question—public documents or at least magazine and newspaper discussions could be obtained and treat the topic as an original investigation. This has been a time absorbing method of instruction and, as has been said before, the student has not been able to cover the whole subject and it has relieved the student from extreme dependence upon the textbook. It has resembled the method of study pursued in the laboratories and it has given vitality to the subject for both student and teacher through the employment of original sources.

We find too that the "opportunist" character of social studies is taken advantage of since we are able to present the economic or political subject which is uppermost in the public mind and which is probably therefore most nearly uppermost in the students mind—a specific application of the adage that teaching should proceed from "the known to the unknown."

The department has received great benefit through its removal from College Hall to the new Agricultural Building. Early in the year Prof. Shaw kindly extended an invitation to myself and associates to come into the new building which was then about to be occupied and the opportunity was gladly accepted. A group of three large offices and two nearby classrooms were found to be at our disposal and the improved efficiencies which resulted from bettered quarters and more convenient classrooms were not slow in manifesting themselves.

In conclusion permit me to commend the faithfulness and industry of each one of my assistants—some of whom have in addition to their departmental work assumed important and exacting duties of a general college nature—which have been so unfailingly shown throughout the past year.

Respectfully submitted,

WILBUR O. HEDRICK.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF MATHEMATICS.

To the President:

I have the honor of submitting the following report of the Department of Mathematics.

It will be remembered that September 1, 1909, the Department of Mathematics and Civil Engineering was divided and the work in Mathematics placed in my charge.

At the opening of the college year it was found that, owing to the great number of sections, more help was necessary, and in consequence of this demand, Mr. H. A. Snepp was secured as instructor in the department. About November 1, 1909, Mr. A. E. Jones, who had been an instructor in the department for a number of years, left on account of illness. It soon developed that he would not return to his work and Mr. R. H. Reece was engaged to fill the vacancy thus made in our departmental force. The following is a list of the members of the department, with the exception of the writer, arranged in the order of seniority of appointment:

M. F. Johnson, B. S., Instructor.
S. E. Crowe, B. A., Instructor.
J. E. Robertson, B. S., Instructor.
E. E. Beighle, B. S., Instructor.
L. C. Emmons, B. S. A. B., Instructor.
K. E. Hopphan, B. S., Instructor.
H. A. Snepp, B. A., Instructor.
R. H. Reece, B. S., Instructor.

Owing to the stress of class work during the first two terms of the year, Mr. W. B. Wendt, of the Department of Civil Engineering, kindly assisted us by instructing a section of analytic geometry in the fall term after the departure of Mr. Jones and a section of differential calculus in the winter term.

I take this occasion to commend the zealous and efficient service of all these men.

Following appears a schedule of the classroom work of the department:

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. of hours per week.	No. of students in class.
Fall term.							
Sub-fresh...	Eng. algebra.....	Math. 1c..	Prof. Babcock.....	2 College Hall.....	3–4	5	17
Sub-fresh...	Ag. and W. alg....	Math. 1..	Mr. Crowe.....	3 Dairy Bldg.....	9–10	5	16
Sub-fresh...	Ag. and W. alg....	Math. 1..	Mr. Crowe.....	3 Dairy Bldg.....	11–12	5	16
Sub-fresh...	Ag. and W. alg....	Math. 1..	Mr. Emmons.....	403 Eng. Bldg.....	11–12	5	23
Sub-fresh...	Eng. alg.....	Math. 1c..	Mr. Snepp.....	2 College Hall.....	9–10	5	17
Sub-fresh...	Eng. alg.....	Math. 1c..	Mr. Snepp.....	8 College Hall.....	3–4	5	20
Sub-fresh...	Ag. and W. alg....	Math. 1..	Mr. Beignie.....	2 Dairy Bldg.....	9–10	5	14
Sub-fresh...	Ag. and W. alg....	Math. 1..	Mr. Beighle.....	302 Eng. Bldg.....	4–5	5	27
Sub-fresh...	Eng. alg.....	Math. 1c..	Mr. Parker, *Jones....	8 College Hall.....	9–10	5	18
Freshmen...	Eng. alg.....	Math. 1c..	Mr. Parker, *Jones....	8 College Hall.....	10–11	5	21
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Parker, *Jones....	8 College Hall.....	8–9	5	23
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Johnson.....	1 Dairy Bldg.....	8–9	5	21
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Johnson.....	12 College Hall.....	10–11	5	19
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Hopphan.....	403 Eng. Bldg.....	10–11	5	18
Freshmen...	Eng. alg.....	Math. 1c..	Mr. Parker, *Johnson..	Abbot Hall.....	1–2	5	25
Freshmen...	Eng. geom.....	Math. 2d.	Mr. Johnson.....	Abbot Hall.....	2–3	5	23
Freshmen...	Eng. alg.....	Math. 1c..	Mr. Hopphan.....	302 Eng. Bldg.....	11–12	5	20
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Hopphan.....	401 Eng. Bldg.....	1–2	5	18
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Hopphan.....	109 Eng. Bldg.....	2–3	5	24
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Hopphan.....	2 College Hall.....	4–5	5	22
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Beighle.....	302 Eng. Bldg.....	10–11	5	19
Freshmen...	Eng. geom.....	Math. 2d.	Mr. Beighle.....	302 Eng. Bldg.....	2–3	5	17
Freshmen...	Eng. geom.....	Math. 2d.	Mr. Snepp.....	2 College Hall.....	8–9	5	24
Freshmen...	Eng. geom.....	Math. 2d.	Mr. Snepp.....	2 College Hall.....	2–3	5	28
Freshmen...	Eng. alg.....	Math. 1c..	Mr. Snepp.....	2 College Hall.....	1–2	5	25
Freshmen...	Eng. geom.....	Math. 2d.	Mr. Emmons.....	Abbot Hall.....	8–9	5	20
Freshmen...	Eng. geom.....	Math. 2d.	Mr. Emmons.....	301 Eng. Bldg.....	2–3	5	21
Freshmen...	Eng. alg.....	Math. 1c..	Mr. Emmons.....	Abbot Hall.....	9–10	5	19
Freshmen...	Eng. geom.....	Math. 2d.	Mr. Crowe.....	3 Dairy Bldg.....	8–9	5	16
Freshmen...	Eng. alg.....	Math. 1c..	Mr. Crowe.....	3 Dairy Bldg.....	10–11	5	17
Freshmen...	Eng. alg.....	Math. 1c..	Mr. Crowe.....	109 Eng. Bldg.....	1–2	5	26
Freshmen...	Eng. geom.....	Math. 2b.	Mr. Robertson.....	401 Eng. Bldg.....	8–9	5	24
Freshmen...	Eng. alg.....	Math. 1c.	Mr. Robertson.....	301 Eng. Bldg.....	11–12	5	20
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Emmons.....	301 Eng. Bldg.....	1–2	5	21
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Robertson.....	401 Eng. Bldg.....	10–11	5	18
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Robertson.....	401 Eng. Bldg.....	2–3	5	21
Freshmen...	Ag. and W. alg....	Math. 1b.	Mr. Robertson.....	401 Eng. Bldg.....	4–5	5	23
Freshmen...	Eng. alg.....	Math. 1c..	Prof. Babcock.....	2 College Hall.....	9–10	5	22
Sophomores.	Anal. geom.....	Math. 5..	Prof. Babcock.....	2 College Hall.....	10–11	5	18
Sophomores.	Anal. geom.....	Math. 5..	Mr. Wendt, *Jones....	8 College Hall.....	11–12	5	22
Sophomores.	Anal. geom.....	Math. 5..	Mr. Johnson, *Jones...	8 College Hall.....	1–2	5	24
Sophomores.	Anal. geom.....	Math. 5..	Mr. Johnson.....	2 College Hall.....	11–12	5	21
Sophomores.	Anal. geom.....	Math. 5..	Mr. Beighle.....	302 Eng. Bldg.....	1–2	5	23

*Mr. Jones resigned November 1, causing these changes.

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. of hours per week.	No. of students in class.
Winter term.							
Sub-fresh...	Eng. alg.....	Math. 1d.	Prof. Babcock.....	2 College Hall.....	8–9	5	18
Sub-fresh...	Eng. alg.....	Math. 1d.	Mr. Snepp.....	401 Eng. Bdlg.....	11–12	5	19
Sub-fresh...	Eng. alg.....	Math. 1d.	Mr. Robertson.....	102 Ag. Bldg.....	8–9	5	17
Sub-fresh...	Eng. alg.....	Math. 1d.	Mr. Hopphan.....	302 Eng. Bldg.....	11–5	5	20
Sub-fresh...	Eng. geom.....	Math. 2..	Mr. Emmons.....	103 Ag. Bldg.....	2–3	3	25
Sub-fresh...	Eng. geom.....	Math. 2..	Mr. Hopphan.....	401 Eng. Bldg.....	2–3	3	25
Sub-fresh...	Eng. geom.....	Math. 2..	Mr. Beighle.....	203 Eng. Bldg.....	2–3	3	24
Sub-fresh...	Ag. and W. alg....	Math. 1a.	Mr. Emmons.....	103 Ag. Bldg.....	10–11	5	16
Sub-fresh...	Ag. and W. alg....	Math. 1a..	Mr. Emmons.....	103 Ag. Bldg.....	11–12	5	13
Sub-fresh...	Ag. and W. alg....	Math. 1a..	Mr. Reece.....	102 Ag. Bldg.....	10–11	5	18
Sub-fresh...	Ag. and W. alg....	Math. 1a..	Mr. Crowe.....	203 Eng. Bldg.....	11–12	5	15
Sub-fresh...	Ag. and W. alg....	Math. 1a..	Mr. Robertson.....	103 Ag. Bldg.....	1–2	5	18
Sub-fresh...	Ag. and W. alg....	Math. 1a..	Mr. Beighle.....	302 Eng. Bldg.....	9–10	5	17
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Emmons.....	103 Ag. Bldg.....	9–10	5	16
Freshmen...	Eng. alg.....	Math. 1f..	Prof. Babcock.....	2 College Hall.....	9–10	5	19
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Hopphan.....	302 Eng. Bldg.....	10–11	5	21
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Hopphan.....	100 Ag. Bldg.....	1–2	5	22
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Reece.....	102 Ag. Bldg.....	1–2	5	20
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Johnson.....	2 College Hall.....	10–11	5	21
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Crowe.....	203 Eng. Bldg.....	10–11	5	21
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Snepp.....	401 Eng. Bldg.....	1–2	5	21
Freshmen...	Eng. alg.....	Math. 1f..	Mr. Snepp.....	401 Eng. Bldg.....	3–4	5	14
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Beighle.....	203 Eng. Bldg.....	3–4	5	13
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Reece.....	102 Ag. Bldg.....	11–12	5	13
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Reece.....	102 Ag. Bldg.....	2–3	5	18
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Johnson.....	103 Ag. Bldg.....	8–9	5	28
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Johnson.....	100 Ag. Bldg.....	3–4	5	14
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Crowe.....	101 Ag. Bldg.....	2–3	5	16
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Crowe.....	100 Ag. Bldg.....	8–9	5	22
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Robertson.....	2 College Hall.....	2–3	5	18
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Robertson.....	2 College Hall.....	3–4	5	18
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Snepp.....	101 Eng. Bldg.....	10–11	5	24
Freshmen...	Ag. and W. geom..	Math. 2b.	Mr. Hopphan.....	302 Eng. Bldg.....	3–4	5	20
Sophomores.	Dif. Calculus.....	Math. 6a..	Prof. Babcock.....	2 College Hall.....	11–12	5	19
Sophomores.	Dif. Calculus.....	Math. 6a..	Mr. Johnson.....	2 College Hall.....	1–2	5	19
Sophomores.	Dif. Calculus.....	Math. 6a..	Mr. Emmons.....	100 Ag. Bldg.....	1–2	5	19
Sophomores.	Dif. Calculus.....	Math. 6a.	Mr. Beighle.....	203 Eng. Bldg.....	1–2	5	19
Sophomores.	Dif. Calculus.....	Math. 6a.	Mr. Wendt.....	111 Eng. Bldg.....	11–12	5	25

Class.	Subject.	No. of course.	Teacher.	Classroom.	Hour of meeting.	No. of hours per week.	No. of students in class.
Spring term.							
Sub-fresh...	Mensuration.....	Math. 3..	Mr. Johnson.....	301 Eng. Hall.....	9–10	5	12
Sub-fresh...	Mensuration.....	Math. 3..	Mr. Johnson.....	100 Ag. Hall.....	3–4	5	16
Sub- fresh...	Mensuration.....	Math. 3..	Mr. Emmons.....	2 College Hall.....	3–4	5	15
Sub-fresh...	Mensuration.....	Math. 3..	Mr. Emmons.....	101 Ag. Hall.....	9–10	5	13
Sub-fresh...	Eng. geom.....	Math. 2c..	Mr. Hopphan.....	403 Eng. Hall.....	11–12	5	16
Sub-fresh...	Eng. geom.....	Math. 2c..	Mr. Beighle.....	403 Eng. Hall.....	8–9	5	12
Sub-fresh...	Eng. geom.....	Math. 2c..	Mr. Reece.....	401 Eng. Hall.....	8–9	5	10
Sub-fresh...	Eng. geom.....	Math. 2c..	Mr. Snepp.....	100 Ag. Hall.....	11–12	5	19
Sub-fresh...	Ag. and W. geom..	Math. 2a.	Mr. Snepp.....	100 Ag. Hall.....	2–3	5	21
Sub-fresh...	Ag. and W. geom..	Math. 2a..	Mr. Robertson.....	100 Ag. Hall.....	9–10	5	13
Sub-fresh...	Ag. and W. geom..	Math. 2a..	Mr. Reece.....	103 Ag. Hall.....	2–3	5	14
Sub-fresh...	Ag. and W. geom..	Math. 2a..	Mr. Crowe.....	103 Ag. Hall.....	9–10	5	14
Sub-fresh...	Ag. and W. geom..	Math. 2a..	Mr. Hopphan.....	403 Eng. Hall.....	2–3	5	15
Freshmen...	Eng. trig.....	Math. 4b.	Mr. Hopphan.....	213 Eng. Hall.....	10–11	5	18
Freshmen...	Eng. trig.....	Math. 4b.	Mr. Crowe.....	103 Ag. Hall.....	8–9	5	12
Freshmen...	Eng. trig.....	Math. 4b.	Mr. Crowe.....	103 Ag. Hall.....	10–11	5	18
Freshmen...	Eng. trig.....	Math. 4b.	Mr. Reece.....	102 Ag. Hall.....	1–2	5	17
Freshmen...	Eng. trig.....	Math. 4b.	Prof. Babcock.....	2 College Hall.....	8–9	5	11
Freshmen...	Eng. trig.....	Math. 4b.	Prof. Babcock.....	2 College Hall.....	10–11	5	16
Freshmen...	Eng. trig.....	Math. 4b.	Mr. Robertson.....	101 Ag. Hall.....	1–2	5	17
Freshmen...	Eng. trig.....	Math. 4b.	Mr. Robertson.....	101 Ag. Hall.....	2–3	5	20
Freshmen...	Eng. trig.....	Math. 4b.	Mr. Snepp.....	100 Ag. Hall.....	1–2	5	20
Freshmen...	Ag. and W. trig...	Math. 4a..	Mr. Crowe.....	301 Eng. Hall.....	2–3	3	15
Freshmen...	Ag. and W. trig...	Math. 4a..	Mr. Beighle.....	2 College Hall.....	2–3	3	16
Freshmen...	Ag. and W. trig...	Math. 4a..	Mr. Beighle.....	2 College Hall.....	3–4	3	27
Freshmen...	Ag. and W. trig...	Math. 4a..	Mr. Reece.....	103 Ag. Hall.....	3–4	3	19
Freshmen...	Ag. and W. trig...	Math. 4a..	Mr. Robertson.....	100 Ag. Hall.....	8–9	3	26
Freshmen...	Ag. and W. trig...	Math. 4a..	Mr. Johnson.....	301 Eng. Hall.....	8–9	3	28
Freshmen...	Ag. and W. trig...	Math. 4a..	Mr. Snepp.....	100 Ag. Hall.....	10–11	3	26
Sophomores.	Integ. Calcul.....	Math. 6b.	Prof. Babcock.....	2 College Hall.....	11–12	5	21
Sophomores.	Integ. Calcul.....	Math. 6b.	Mr. Johnson.....	302 Eng. Hall.....	11–12	5	21
Sophomores.	Integ. Calcul.....	Math. 6b.	Mr. Beighle.....	2 College Hall.....	1–2	5	26
Sophomores.	Integ. Calcul.....	Math. 6b.	Mr. Emmons.....	103 Ag. Hall.....	1–2	5	28

It will be seen that the work of the fall term is considerably heavier than that of the other two; there being 43 sections daily during that term as against an average of 36⅘ and 30⅕ during the winter and spring respectively. I have as yet no remedy to propose for this unequal distribution of the work through the year.

Respectfully submitted,

WARREN BABCOCK,
Professor of Mathematics.

East Lansing, June 30, 1910.

REPORT OF THE DEPARTMENT OF MILITARY SCIENCE.

To the President:

Sir: I have the honor to submit the following report of the Military Department for the year ending June 30, 1910:

During the first half of the fall term the new cadets were divided into squads of four and later eight men and instructed in the school of the soldier and squad by sophomore candidates for appointment as corporal, under the supervision of the captains and one lieutenant of each company. The old cadets were instructed in the school of the company by the other lieutenant of each company. During the second half of the fall term the new cadets were instructed indoors in the manual of arms and in the school of the squad and company by their cadet officers. They also attended three lectures given by their cadet majors on the subject of Organization, Field Service Regulations, U. S. Army.

Also, during the second half of this term the sophomores had twelve recitations in Infantry Drill Regulations, U. S. Army.

At the beginning of the winter term the instruction of the new cadets was continued as outlined above. In order to relieve the crowded condition in the armory and to give the students a better knowledge of military affairs in general and a more accurate knowledge of the details of drill, the schedule of instruction, with the approval of the president of the college, was modified at the end of January. The new schedule required in each week one drill, one recitation, and one lecture.

The lectures were given by the head of the department on subjects of general military interest. The recitations were on Infantry Drill Regulations, U. S. Army. The recitations were conducted by cadet officers in a very satisfactory manner. The interest taken by the students in this work was quite encouraging, and I think good results were reflected by the drill and appearance of the corps at the annual inspection.

The sophomores continued in twelve recitations their study of Infantry Drill regulations, completing the school of the company and taking up and completing the school of the battalion and ceremonies.

During the second half of the winter term all classes were due for drill. The new cadets continued on the same schedule as during the first half of the term. Sophomores, juniors, and five-year freshmen reported for drill once each week with their companies and for lectures once each week. This schedule was continued until the end of the term. By this schedule each captain had his entire compnay once each week for drill, and with only two companies in the armory at one time, fairly satisfactory instruction could be given.

A new battalion of three companies was organized at the beginning of the spring term. This was found necessary to meet the rapid growth of the corps and to promote the main object of this instruction; namely, to qualify students to be company officers of infantry, volunteers or militia. To carry out this object it is deemed desirable to reduce the

strength of the companies and promote more men to positions of responsibility and command.

The cadet regiment now lacks but one company and this can doubtless be organized next session.

The cadet majors supervised the instruction of their respective battalions, and feeling the responsibility and trust reposed in them, rendered excellent service. The office of cadet lieutenant-colonel was created in January and the officer promoted to that position was of great assistance in the administration and instruction of the corps. Unfortunately, he was absent on account of sickness during almost the entire spring term.

At its March meeting the State Board of Agriculture authorized the employment of a retired noncommissioned officer, U. S. Army, as assistant in the department. Sergeant P. J. Cross, Corps of Engineers, U. S. Army, retired, having been employed, reported for duty on April 8. His services have been most valuable.

All instruction during the spring term, except gallery practice and aiming, was given outdoors. The instruction embraced the school of the company and battalion in close and extended order, evolutions of the regiment, battalion and regimental parade, review and inspection, guard mounting, gallery practice firing and aiming drill.

The corps was reviewed and inspected on May 12, by Brigadier General Carl A. Wagner, Inspector General of Michigan, and made a very creditable showing. The following extract is taken from his letter to the president of the college: "I have had the honor of inspecting this corps of cadets on several former occasions, and have seen a marked improvement in the military appearance, steadiness and precision of execution of their military duties each succeeding time, and on the 16th inst., in my judgment, they made the best appearance and showing I have yet seen them make." The drill and ceremonies referred to as on the 16th was the annual inspection which General Wagner also witnessed, as noted below.

The annual War Department inspection was made May 16 by Captain Peter C. Harris, General Staff, U. S. Army. His report has not yet been received. The exercises and maneuvers given at inspection were:

Regimental review and inspection.

Regimental drill, close order.

Each battalion extended order, and the 2nd Batt. formed in normal attack.

1st and 3rd Batts., close order drill.

2nd Batt. formed as an advance guard.

Cos. "A," "B," and "C," company drill, extended order.

Hospital corps drill and administering first aid to the injured.

The inspector also witnessed a portion of the company competitive drill hereinafter referred to.

The inspector's attention was invited to the fact that the middle of May is too early for an inspection at this institution, and it is thought that future inspections will be somewhat later.

A number of prominent officers of the Organized Militia of Michigan were present at the inspection, and the following named acted as judges of the company competitive drill which followed the inspection: Briga-

dier General Carl A. Wagner, Col. James N. Cox, Adjutant General, and Lieutenant Amos H. Ashley, Battery "A," First Artillery. In the competitive drill, taking into account also the appearance and steadiness in ranks during inspection, Co. "D," Captain H. E. Lynch, was awarded first place, Co. "L," Captain C. W. McKibbin, second, and Co. "H," Captain H. H. Douglass, third.

On May 25 a regimental parade was witnessed by Brigadier General W. T. McGurrin, The Adjutant General and Chief of Staff, of Michigan. He was accompanied by several other prominent officers of the Michigan National Guard.

The instruction of the Hospital Corps was most satisfactorily conducted by Cadet Sergeant E. C. Lindemann. In addition to the usual work of the Hospital Corps, he gave two lectures to the new cadets on first aid to the injured, which were of practical, every day value, outside of their purely military aspect.

Instruction in visual signalling was given to some fifteen cadets by the Cadet Signal Sergeant.

The instruction of the band was conducted by Prof. A. J. Clark in a most excellent and satisfactory manner. In addition to the purely military work, the band turns out for athletic events, mass meetings, and during the spring term gave regular concerts on Wednesday evenings. The band adds a great deal, I think, to the life of the college, and should be encouraged. The band had this year five senior classmen, whose work with it greatly tended to its improvement.

Altogether, 911 students have been registered in the department during the year. This number includes those excused on account of disability, athletics, etc. Six hundred and fifty-seven (657) were under instruction at the date of the annual War Department inspection, of whom 633 were present under arms, in uniform.

Since last report two former officers of the corps and one other graduate of the college have been appointed as second lieutenants in the U. S. Coast Artillery Corps. Four of the cadet officers of this year's graduating class have been designated by the War Department to take the competitive examination.

I desire to express thanks to the cadet officers of the corps, without whose loyal support the corps could hardly exist. Thanks are particularly due to the senior classmen who have acted in the capacity of field and staff officers and company commanders. They took the work without expectation of great reward and have filled satisfactorily positions requiring executive ability, tact, patience.

Very respectfully,

G. M. HOLLEY,

1st Lieut., 11th Infantry, Prof. Mil. Sc. and Tactics.

East Lansing, June 30, 1910.

Doc. 133, Mil. Dept.

REPORT OF THE DEPARTMENT OF PHYSICAL CULTURE AND ATHLETICS.

To President J. L. Snyder:

Dear Sir: I have the honor to present to you the following report of the work of the Department of Physical Culture and Athletics for the year ending June 30th, 1910.

The work of the representative athletic teams has been very good in all branches; the football team was probably the strongest ever to represent the institution, and brought considerable recognition to the college by defeating such strong western teams as Wabash, Marquette and De Paul; the basketball team won the state championship; while the baseball, track, tennis and indoor teams all had successful and interesting seasons.

A great effort was made during the year to interest as large a number as possible of the young men of the college in some sort of work of the department, and the result was very gratifying. Regular class work was given during the winter, which consisted of the usual dumb bell, Indian club and wand drills, breathing and setting up exercises, and apparatus work, and a large number, especially under classmen, took advantage of it. Throughout the year interclass and interhall contests in all of the sports were arranged, and the interest was very keen at all times. A squad in cross country running, a splendidly healthful exercise, was maintained throughout the year, and as many as one hundred and fifty were enrolled for this work at one time.

I wish to again call your attention to the necessity for a gymnasium in the immediate future. With no gymnasium, the work of the department is so handicapped that it is impossible to make any progress along the lines of true physical education for all the men. A physical examination should be made of every boy entering college, followed by a compulsory course in hygiene sanitation, clean living and physical exercise. This must be done if the department is to take rank on a par with the department in other institutions, but is impossible under present conditions.

The athletic field was materially improved during the year. A substantial baseball bleacher, with paddock arrangement, was built, the cinder track was improved, and many minor improvements added. In all there was transferred about twelve hundred dollars from the receipts of athletic contests and expended in permanent improvements on the field.

The receipts from the bath house have been about fifteen hundred dollars. Over nine hundred of the young men, an unusually good per cent, elected to pay the one dollar and fifty cents fee. This amount has been amply sufficient to take care of the running expenses of the department for the year.

The invitation inter-high school meet, the fifth annual to be given under the auspices of the department, showed a healthy growth over

previous years. Invitations were sent to every high school in the state, and nearly fifty responded by sending substantial delegations to visit the college.

Respectfully submitted,
C. L. BREWER,
Director.

East Lansing, Mich., June 30th, 1910.

REPORT OF THE DEPARTMENT OF ZOOLOGY AND PHYSIOLOGY.

To the President:

Sir: I have the honor to submit the following report of the Department of Zoology and Physiology, and the General Museum, for the year ending June 30, 1910:

As indicated last year the growth of the college and consequent increase in the size of classes necessitated a corresponding increase in the teaching force of this department. At the opening of the fall term a new instructor was engaged, Mr. H. S. Osler, a graduate of Muskingum College, Ohio, who has rendered good service in the classes in physical geography, geology, anatomy and elementary zoology. In the spring term additional help in the zoological laboratory became imperative and Mr. J. L. Whitney, of the graduating class, was secured for fourteen hours per week. The department staff for the year therefore has been made up as follows:

Assistant Professor, Jesse J. Myers.

Instructors, Benj. B. Roseboom, Frederick A. Burt, Harold S. Osler, J. L. Whitney.

Stenographer and typewriter, Marcia A. Carl.

A student, W. C. Spratt, was also employed regularly on Sunday afternoons as an attendant in the General Museum, since it has been customary always to keep the museum open to the public part of that day, and experience has demonstrated that it is not wise to leave it unprotected at such times.

It is a pleasure to record that the work of the several members of the department during the past year has been all that could be expected or desired, and this despite the fact that the amount of work required of each has been far in excess of that demanded in several of the departments where similar salaries are paid. We are fortunate furthermore in being able to retain all the instructors for the coming year. It will, however, be absolutely necessary to add one more assistant, and in my opinion the employment of an additional man in the capacity of special museum aid would be money well expended.

The number and disposition of classes, sections, students and instructors are shown in the following table:

Schedule of classes, 1909-1910.

Term.	Subject.	Course.	Class.	No. students.	No. sections.	Instructors.
Fall.....	Geology 1a.....	Agr., for.....	Sophomore..	102	4	Barrows, Myers, Roseboom, Burt.
Fall.....	Geology 1b.....	Home Econ.....	Sophomore..	56	2	Barrows, Myers, Roseboom.
Fall.....	Geology 2a.....	Agr., for.....	Senior-Jun..	21	1	Barrows, Burt.
Fall.....	Phys. Geog. 1a..	Agr.....	Sub-Fresh..	68	4	Myers, Burt, Osler.
Fall.....	Phys. Geog. 1b..	Home Econ.....	Sub-Fresh..	32	2	Myers, Burt, Osler.
Winter..	Zoology 2a.....	Agr., for.....	Senior-Jun..	21	2	Barrows, Myers, Roseboom, Burt.
Winter..	Zoology 2b.....	Home Econ.....	Senior-Jun..	3	1	Barrows, Roseboom, Burt.
Winter..	Anatomy 1a....	Agr., for.....	Sophomore..	108	4	Myers, Roseboom, Burt, Osler.
Winter..	Anatomy 1b....	Home Econ.....	Sophomore..	53	2	Myers, Roseboom, Burt, Osler.
Spring...	Zoology 1a.....	Agr., for.....	Freshman...	147	6	Barrows, Myers, Roseboom, Burt, Whitney, Osler.
Spring...	Zoology 1b.....	Home Econ.....	Freshman...	68	4	
Spring...	Zoology 3a.....	Agr., for.....	Senior-Jun..	24	2	Barrows, Myers, Roseboom.
Spring...	Zoology 3b.....	Home Econ.....	Senior-Jun..	4	1	Barrows, Myers, Roseboom.
Summer.	Ornithology.....	Summer school..	Teachers...	11	1	Barrows.
Total.....				718	36	

I would renew my recommendations of last year for the transposition of the courses in anatomy and elementary zoology. The experience of the past year fully sustains the opinion previously expressed, that the work in human anatomy and physiology unquestionably ought to precede that in general or elementary zoology, unless possibly an entire year could be given to the latter subject. It was at first assumed that all students entering college would have some knowledge of human anatomy and physiology, since that subject is commonly taught in the grades, as well as in high schools; experience shows, however, that each year a very considerable proportion (probably 20% to 30%) of the students classified for elementary zoology are entirely ignorant of the most fundamental facts of human physiology, so that they are seriously handicapped in the study of zoology. When it is remembered that a clear understanding of the vital processes of animals is absolutely essential to the proper comprehension of many of the more advanced studies, not only in this but in other departments, the gravity of the present arrangement becomes manifest. Chemistry, physics, zoology, botany, and geology are the foundation stones of a sound agricultural education, yet their importance has been very largely ignored in the present course of study, apparently in order to make room for single terms or half terms of subjects which belong more properly to the later years of the course or even to post-graduate courses.

Two full terms of general zoology and one of comparative anatomy should be required of every student in the agricultural courses with an opportunity to elect at least two more terms, probably including embryology and histology. Similarly, two full terms of geology should be

required in all courses, except possibly the Home Economics course, and at least one additional term of elective geology or mineralogy.

The liberality of the Board in regard to equipment is most fully appreciated, and the department at present is better prepared than ever before to make the courses in geology, embryology and comparative anatomy thoroughly practical and helpful. The new stereopticon (Balopticon) with microscope attachment and cooling devices has been specially helpful in the classes in anatomy and embryology, and the increased number of compound microscopes renders the laboratory work in these subjects more satisfactory than ever before. In common with most other departments we suffer more or less from lack of class and laboratory room, but have been able thus far to make temporary arrangements which permit of fair work. The time, however, is not far distant when the department will need an entire building with the modern facilities and appliances which advanced biology demands.

The General Museum, which comes under the care of this department, merits more than a passing notice. Owing to its location on the second floor of the Library Building, and to the overcrowded condition of its cases, its size and importance are usually much underestimated. No special fund is set apart for it, and the only care bestowed upon it is such as can be given by the members of the teaching force of the department when they can be spared from academic work. From the fact that its collections are constantly drawn upon for illustrative material in laboratory and classroom, a considerable amount of such work is absolutely necessary, and each and every member of the department staff is required from time to time to make himself useful in the museum. The average amount of actual class work assigned to an instructor is about twenty-four hours per week, in addition to which at least six or eight hours per week is required for getting, preparing and preserving material for the laboratory work and demonstrations. This leaves little time for systematic work in the museum, yet during the past year much has been done to increase, improve and arrange the collections. Hundreds of donations are received every year, most often from actual students who become interested in some particular branch of science, but many also from former students, whether alumni or not, and also from friends throughout the state and elsewhere. Five years ago every available foot of case room in the main hall appeared to be occupied and every case was crowded to overflowing, yet within two years two separate collections of birds and mammals have been received as gifts in which the aggregate number of specimens exceeded one thousand. The first of these, the Broas Collection, was a museum in itself, consisting of upwards of eight hundred specimens of mounted birds and mammals, mainly collected in Ionia County, Mich., mounted by the late Levi Broas of Belding, and presented to the college by his heirs in April, 1910. By the removal of an old table case and the storage of the specimens it contained, space was obtained for a new wall case in which a small part of the Broas Collection has been placed on exhibition, the remainder being stored in sealed cans and boxes until more room can be had.

The second collection referred to came as a gift from one of our alumni, Mr. D. S. Bullock, the class of 1902, now located at Temuco, Chili, S. A., as a missionary among the Indians. In his spare time Mr.

Bullock collected and prepared the skins of nearly two hundred birds and mammals of that little known region and on his return last summer (July, 1909) he brought this beautiful collection with him and presented it to the college. Most of the specimens have been nicely mounted and are now displayed in one of the large museum cases whose former contents have been temporarily stored.

It may interest some to know that the General Museum of this college exceeds in size and importance that of any other educational institution in the state, with the single exception of the University Museum at Ann Arbor. It is specially rich in local (that is Michigan) specimens, and it has been the aim of this department during the past sixteen years to build up the collections in this way especially. Animals of all kinds, mammals, birds, reptiles, minerals, fossils, and curios from all parts of the world are received gratefully of course, but we have tried never to lose sight of the educational value of the museum to the college students and hence have aimed to give them the opportunity to become familiar with the varied natural forms, animate and inanimate, of their own state. The specimens on exhibition go far toward realizing this aim, yet we have thousands of good specimens of rocks, minerals, fossils, shells, Indian relics, etc., stored away in cellar and attic for lack of room to display them. The total value of the museum collections (displayed and stored) is placed at a little more than sixteen thousand dollars, exclusive of cases, but there are numerous single specimens which are almost priceless and could not be replaced at any cost. Many of these specimens are fragile, perishable, and liable to destruction at any time through a little thoughtlessness or neglect, and, as already stated, it seems simply a matter of common prudence on the part of the college to employ at least one assistant who can give much, if not most, of his time to these valuable collections.

Nor is this all. The collections are such as any college might be proud of, and they are a source of pride and gratification to scores of thousands of citizens who visit the college each year and gather pleasure, information and inspiration from each visit. Such collections are worthy of a better setting and although several new buildings are needed an impartial canvass of the needs of the several departments will show clearly that the Department of Zoology, Physiology and Geology, with its large and increasing museum, has a stronger claim for a new building than any other single department. The existing collections alone, if properly displayed, would fill three times the space now available—in fact would occupy the entire building now allotted to library, museum, offices and laboratories. This building, however, is not only too small to accommodate the museum and the academic section of the department, but it is ill adapted in many ways for such a purpose. Its foundations are insecure, the walls are cracked, the floors warped, the roof not weather tight. The settling of the floors has twisted the large museum cases so that many are no longer insect-proof and can be used only for such specimens as are not liable to injury by pests or dust.

A new museum building of ample size and modern construction, with laboratory and lecture accommodation for our largest classes in zoology, geology and anatomy, is one of the imperative needs of the college, anything less must be insufficient and temporary at best.

The demands of the classroom have been such that we have found little time for three years past to carry forward the bulletin on Michigan birds which was begun six or seven years ago. A considerable part of each summer has been spent on the work and now for two years it has been almost complete. As it now stands it consists of about twelve hundred manuscript pages (typewritten) and embodies the life-histories of all known species of Michigan birds, with nearly two hundred cuts (uncolored). At present the artificial keys are being prepared for the identification of species, and as soon as this is done the work will be ready for the press and if suitable arrangements can be made for its publication it should be issued at once.

Respectfully submitted,
WALTER B. BARROWS,
Professor of Zoology and Physiology, and Curator of General Museum.
East Lansing, Mich., June 30, 1910.

REPORT OF THE LIBRARIAN.

To the President:

Sir: The following is the report on the Library for the year ending June 30th, 1910. Ten hundred twenty-six volumes have been added during the year, of which five hundred twenty-two were purchased, ninety-two were gifts, and four hundred twelve volumes came by binding.

Three hundred fifty unbound volumes and pamphlets were presented to the library, and acknowledgement made in all cases where the donor was known.

For bound volumes we are indebted as follows:

American Shorthorn Breeders' Ass'n, 1.
American Hampshire Down Ass'n., 1.
American Herford Ass'n., 1.
American Saddle Horse Ass'n., 1.
American Breeders' Ass'n., 1.
Baker, R. S., 1.
Burrows, Hon. J. C., 1.
Casson, H. N., 1.
California Fruit Growers' Ass'n., 1.
Collinge, W. E., 1.
Holstein-Friesian Ass'n., 2.
Hawley, F. B., 1.
Haner, Mrs. J. K. L., 1.
Iowa, 1.
Indiana, 1.
Kedzie, Prof. F. S., 1.
Kentucky, 1.
Longyear, B. O., 1.
Maine, State Board of Agriculture, 11.
Massachusetts, 2.
Missouri Board of Horticulture, 1.
Missouri Botanical Garden, 1.
Michigan reports, 13.
Michigan Academy of Science, 1.
New Jersey, 1.
New S. Wales, 1.
New York, 5.
Pennsylvania, 3.
Raymond, Geo. L., 11.
Smithsonian Institution, 5.
Swift, Ivan, 1.
Tennessee, 1.
Tomlinson, W. A., 1.
United States reports, Agriculture Dept., 2.

Education Bureau, 3.
Interstate Commerce Commission, 1.
Navy Dept., 1,
Treasury Dept., 1.
Also volumes received from the Supt. of Documents on account of Depository Library.
United States Brewers' Ass'n., 1.
Vermont, 1.
Wisconsin, 1.
Wilson, Prof. V. T., 1.

In the reading room may be found four hundred sixty-six periodicals, foreign and American, either purchased by the college, or received as donations and exchanges. The publications thus received are as follows:

Adrian Times.
Agricultural Gazette of N. S. Wales.
Agricultural Advertising.
Agricultural Student's Gazette, England.
Allegan Gazette.
American Cheesemaker.
American Economist.
American Missionary.
American Poultry Advocate.
American Sheepbreeder.
American Sugar Industry.
American Swineherd.
American Thresherman.
Arboriculture.
Agricultural Ledger, Calcutta, India.
Ann Arbor Argus.
Armada Graphic.
Arrow, The
Australiasian.
Bay City Times.
Battle Creek Journal.
Bear Lake Beacon.
Belding Banner.
Berkshire World and Corn Belt Stockman.
Better Fruit.
Bulletin of the College of Agriculture, Tokio.
Chicago Live Stock World.
Canadian Farm.
Church Helper.
Canadian Horticulturist.
Cattle Specialist.
Chicago Daily Farmers' and Drovers' Journal.
Chicago Packer.
Christian Herald.
Columbia University Quarterly.
Congressional Record.
Daily Drovers' Journal and Stockman, Omaha.
Dakota Farmer.
Electrical Times.
Economic Bulletin.
Farm and Fireside.
Farm and Home.
Farm Life.
Farm News.
Farm World.
Farmers' Advocate.
Farmers' Guide.
Farmers' Voice.
Florists' Exchange.
Garden.
Garden Magazine.
Gleaner.
Gleanings in Bee Culture.
Good Health.
Grand Ledge Independent.
Hawaiian Forester.
Hillsdale Leader.
Hillsdale Standard.
Hoard's Dairyman.
Holstein-Friesian Register.
Holstein-Friesian World.
Home and Farm.
Homestead.
Horseshoers' Journal.
Horse World.
Improvement Era.
India, Dept. of Agriculture, Report.
Memoirs (Botanical series.) Research Inst., Pusa.
Memoirs (Entomological series).
Agrl. Journal of India Series, Pusa.
Indian's Friend.

Indiana Farmer.
Illuminating Engineer.
Iowa Horticulture.
Journal of the College of Agriculture, Tokio.
Jamaica Dept. of Agriculture, Bulletin.
Jenner (now Lister) Institute of Preventive Medicine.
Jersey Bulletin.
Johns Hopkins Univ. Circulars.
Journal of Agriculture, Australia.
Journal of Agriculture, Victoria.
Journal of the Board of Agri. and Fisheries, England.
Kalamazoo Telegraph.
Kansas Farmer.
Kimball's Dairy Farmer.
Labor Digest.
Lansing Journal.
Lawton Leader.
Lewiston Journal.
Live Stock Journal.
Live Stock Report.
Mark Lane Express.
Michigan Dairy Farmer.
Michigan Farmer.
Michigan Mirror.
Michigan Presbyterian.
Midland Farmer.
Milchwirtschaftliches Centralblatt.
Missouri Valley Vet'y, Bulletin.
Moderator-Topics.
National Stockman and Farmer.
N. Y. Meteorology. (Draper's Hourly readings).
N. Y. Produce Review.
Ohio Farmer.
Official Gazette, U. S. Patent Office.
Orange Judd Farmer.
Oregon Agriculturist.
Owosso Press American.
Poultry Keeper.
Practical Dairyman.
Park and Cemetery.
Philippine Agrl. Review.
Practical Farmer.
Publicity Magazine.
Records of the Australian Museum.
Redman.
Reliable Poultry Journal.
Republic. Rockefeller Institute for Medical Research, Studies.
Rural Advocate.
Rural N. Yorker.
Southern Farm Magazine.
Saginaw Evening News.
State Republican, Lansing.
Southern Cultivator.
Special Crops.
Successful Farming.
Twentieth Century Magazine.
Tuscola County Advertiser.
Western Society of Engineers, Journal.
Wallace Farmer.
Washington Acad. of Sciences, Proceedings.
Weather Review.
Wilson Bulletin.
Writer.

The publications received by the M. A. C. Record in exchange are also placed in the reading room, and the catalogues of leading educational institutions of the country are received and filed in the office of the librarian.

The publications of the various experiment stations of the country, and the publications of the U. S. Dept. of Agriculture are also received and filed, together with the card indexes which cover all publications issued by the state experiment stations as well as those of the U. S. Dept. of Agriculture.

The library hours remain practically unchanged. On Saturday nights and on Sundays the library has been in charge of Mr. K. D. Van Wagenen, whose services we believe have been entirely satisfactory.

For our regular assistant we have only words of commendation. She is to remain with us for another year.

The number of books drawn from the library during the year was six thousand nine hundred fifty-three. No attempt is made to record the books used in the library.

Fines to the amount of $39.86 have been collected.

We have as yet been unable to remove our books from the room in the Engineering Hall to the room in the new Agricultural Building which the dean of agriculture has so kindly set apart for our use. We hope soon to have shelves placed in this room, when the change will be made. During the winter term the professor of English removed his office from the rear of the library to a room in College Hall, and the room thus vacated was placed at the disposal of the librarian. Shelves have been placed, and the room is used for the more valuable sets of bound scientific periodicals.

We have also been allowed to use a room in the basement of the library building which was formerly used as a bulletin room. These changes have somewhat relieved the crowded condition of the library, and enabled us to improve the appearance of the library, but the inconvenience of having our library books stored in so many different places is great, and we hope that the long needed new library building may soon be erected.

To the library of the Experiment Station two hundred seventy-six books have been added, of which one hundred fifty were purchased, one was a gift, (Prof. U. P. Hedrick, Grapes of New York) and one hundred twenty-five came by binding.

The college library now numbers 28,824 volumes. The experiment station library contains 3,000 volumes. Total in both libraries, 31,824 volumes.

Included in this total are all books in department libraries, so far as they have been catalogued.

Respectfully submitted,
LINDA E. LANDON,
Librarian.

East Lansing, June 30, 1910.

REPORT OF SUPERINTENDENT OF FARMERS' INSTITUTES.

President J. L. Snyder:

Dear Sir: I am very glad to report increased interest in the Farmers' Institutes in all parts of Michigan. Not only have there been more calls than in previous years but the meetings have been more evenly distributed and, where the conditions have been in any way favorable for them, the attendance has been large and the general interest excellent. In a very large number of places the largest halls available were not able to even provide standing room. Wherever there has been any lack either in attendance or interest it can be ascribed to some one of several conditions that may have prevailed at the time the meeting was held. Quite a number of meetings had to be given up entirely owing to severe storms which made it impossible for the speakers to reach the

halls and in other cases the roads were so badly blocked that the attendance was greatly reduced. Had the weather been as pleasant as in 1908-09 the total attendance would have been increased by several thousand.

The local arrangements are cared for by the officers of the county institute societies under the direction of the secretary. In a majority of the counties the officers have had several years of experience and as they know just what should be done to arrange the program and advertise the meetings, there is never any question but what the local arrangements will have proper attention. In a considerable number of counties, however, the secretaries have had no experience with institute work and although the work was done to the best of their knowledge and ability it was not always as effectual as that of some of the secretaries who had had years of experience. In several counties mistakes were made in the selection of local managers and it was found when too late that although there was abundant local interest to have a successful institute, the work of arranging for it had been neglected by the local manager and the meeting had to be given up. Such other matters as outbreaks of smallpox, funerals, revival meetings, lecture courses and gatherings of various kinds were frequently reported as having reduced the attendance.

INSTITUTE LECTURERS.

The increase in the number of students and the introduction of additional short courses at the college lessened the assistance that could be secured from the college faculty and it became necessary to rely more than ever upon outside help.

Practically all of the lecturers who have been in the service were secured for the work of the past year and several new ones were added. The reports received from the officers of the county institute societies show that better work has been done by them than in previous years and it has been seldom that anything but praise has been spoken of the lecturers.

The normal schools as usual were of assistance, furnishing speakers upon educational topics for the afternoon and evening sessions both of the one-day and of the county institutes. President D. B. Waldo and Professor Ernest Burnham of the Western Normal College at Kalamazoo were particularly helpful and rendered splendid assistance.

ONE-DAY INSTITUTES.

During the year 329 one-day institutes were held in 63 counties, with an attendance of 84,906. The usual custom of sending but a single speaker upon farming topics who would occupy about one-half of the time has been followed. A very large number of counties have held as many as twelve one-day institutes, while in a few others the number has been as many as fifteen. The plan of asking the members of the county institute societies to entertain the state speaker while in the county, and to transport him from one institute to the next whenever it is necessary to drive, has greatly reduced the expense of the institutes and to a corresponding degree has increased the number which it is possible to hold with the funds appropriated for farmers' institutes. While

the attendance per session does not average as large as at the county institutes, and the interest as a rule is not as good, the reports that come to me show that they certainly have their place in the institute organization. They are held in most cases in the smaller villages, or perhaps in the country schoolhouses, churches and grange halls, and thus make it possible for thousands of persons to attend who otherwise would not be able to reach an institute. The expense per session of the institutes, with a single state speaker, as compared with two-day institutes for which three or four speakers are generally furnished is never more than one-fourth, and oftentimes less than one-sixth as great as for the latter meetings.

Where local speakers have been secured to fill out the program and that part is properly carried out there is no reason why the one-day institutes cannot be made very interesting and profitable. It is sometimes urged that two or more speakers should be furnished for the one-day institutes, but when this is done it will lessen by one-half the number of such institutes that can be held and, in a state in which farmers' institutes have been held for nearly thirty-five years and where there is a grange or farmers' club in nearly every community, it would seem that there should be no difficulty in securing two or perhaps three local speakers to take part in the program.

TWO-DAY INSTITUTES.

With a few exceptions, and these almost entirely in the Upper Peninsula, all of the counties have had at least one two-day institute for which two speakers upon farming topics and in most cases a lady speaker upon household economics as well as one for educational topics for one session have been supplied.

Not only is there a marked increase in the cost of institutes because they last two days instead of one and from the larger number of speakers furnished, but the hotel bills and traveling expenses of the speakers are paid and this alone for a single speaker generally exceeds the entire cost of a one-day institute.

Although in most cases but a single two-day institute is held in a county, and this is usually called a county institute, a few requests have been received for the holding of one or more additional two-day institutes. These have generally been granted with the understanding that when the speaker remains two days in a place only one-half as many meetings can be held as when the meetings last but one day.

ROUND-UP INSTITUTE.

According to the rule of rotation, which has been in practice for the past fifteen years, the Round-up Institute for 1910 was held at the Agricultural College in the large auditorium of the new Agricultural Building.

In the making up of the program, an endeavor was made to place the leading stress upon Soils and Crops as the institute formed one of the series of Farmers' Weeks at the College. The three general topics of soils, fertilizers and farm crops were assigned respectively to Professor J. A. Jeffery, Professor F. S. Kedzie and Professor V. M. Shoesmith.

each of whom was requested to deliver four lectures which should be the introduction of a series of twelve or more, and one hour of each day of the institute was devoted to the consideration of each of the above topics. The lectures so far as they have been furnished are printed in the report of the proceedings.

The afternoon and evening sessions were arranged after the plan which has been in vogue in previous years—addresses being made by specialists upon topics related to farm life in general. The topics for Wednesday afternoon were directly connected with dairying and included alfalfa culture, the silo, cow testing associations and the improvement of dairy stock. On Thursday afternoon, potato culture, planting and care of orchards and renovating old orchards received attention. For Friday afternoon live stock topics occupied most of the time.

The speakers for the afternoon sessions, in addition to a number of the regular institute lecturers, included Mr. H. F. Probert of Jackson, Prof. A. L. Haecker of the University of Nebraska, Prof. R. S. Kellogg of the U. S. Forest Service, Prof. Wendell Paddock of the Ohio State University and Hon. Colon C. Lillie, Deputy Dairy and Food Commissioner.

Arrangements were made to devote a part of one evening to a presentation of the agricultural possibilities of the counties in northern Michigan. Hon. Alexander Forsythe of Standish, representing the Northeastern Michigan Development Association, spoke upon, "The Land of the Red Clover," and a speaker was promised by the Western Michigan bureau upon the topic, "A Farmer for Every Forty," but the speaker failed to appear.

Excellent music was furnished for the afternoon and evening programs by college talent for the most part. The musical program was in charge of Miss Louise Freyhofer, of the music department of the college. The selections by the M. A. C. choir on Wednesday evening and by the M. A. C. Band on Tuesday and Thursday evenings were highly appreciated. Through the kindness of Superintendent Lawson of the State Industrial School for Boys, the Industrial School band was present on Wednesday afternoon and supplied music for the general session as well as for the women's section.

WOMEN'S CONGRESS.

Three sessions of the Women's Congress were held during the week. The program was mainly filled by members of the institute lecture force and the college faculty. After the program was printed we were fortunate enough to secure the services of Miss Martha Van Rensselaer who is in charge of the Farmers' Wives' Reading Course of Cornell University. The addresses by Miss Van Rensselaer at the Women's Congress as well as her remarks at the general session elicited very favorable comments.

DEMONSTRATIONS.

Throughout the Round-up week various demonstrations were given by a number of the college departments. The Electrical Engineering

Department showed a private electric lighting plant in operation; the Bacteriological Department had an exhibit of specimens of hog cholera, tuberculosis, as well as milk and vinegar starters and nitro-culture; the Department of Farm Crops had on exhibition samples of corn and other grains and the Horticultural Department had an exhibit of spraying materials and machinery and gave a spraying demonstration on Thursday afternoon. Visitors were also welcomed in other departments of the college and many persons availed themselves of the opportunity to inspect the college barns, poultry houses, greenhouses and the library and museum. The ladies, in particular, visited the classes in cooking, dressmaking and millinery and were present at the physical culture exercises in the women's building.

INSTITUTE TRAINS.

During the last week in March and the first week in April a Farmers' Institute Train made a run for ten days over some of the lines of the Michigan Central and Pere Marquette railroads. The train consisted of three coaches in which lectures were given, and four baggage and express cars which were used for exhibits and demonstrations along the line of farm crops, fruit growing, poultry raising, dairying and bacteriology, the latter being especially devoted to demonstrations of the importance of nitro-culture for clover, alfalfa and other legumes and exhibits of hog cholera and tuberculosis.

Although the train was out at the same time as in previous years, when the dates have been found satisfactory, the weather during the period was so favorable for farm work that the attendance of farmers was unusually small although the number at the train at several points was as great as could be handled to advantage.

Numerous requests for farmers' institute trains were received from the railroads in the northern part of the state and as the statement had frequently been made that the best time for holding institutes in that section was between the planting and haying seasons, it was thought advisable to run an institute train over the Detroit and Mackinac road from Bay City to Cheboygan, thence to Bay City over the Michigan Central and from there to Clare over the Pere Marquette. The train was equipped about as for the earlier trip except that one car was occupied with representatives of five breeds of sheep and demonstrations of dipping and shearing sheep and tying the wool.

The results in the way of attendance and interest were very satisfactory. At several points there were fully 450 persons present and at an evening meeting at Cheboygan about 1,000 visited the exhibit cars and listened to the addresses.

We were favored by the presence and assistance on the train of Prof. V. N. Shoesmith and Instructors W. B. Liverance, Geo. A. Brown and H. L. Kempster from the college. Professors C. B. Smith and J. C. McDowell of the Farm Management Bureau, U. S. Department of Agriculture, were also on the train during the entire trip and their addresses were particularly valuable owing to the fact that for the last two or three years their entire time has been devoted to studying crop conditions in Northern Michigan and the methods employed by the more

successful farmers. Their addresses included such topics, as potato culture, clover seed growing, sand vetch, controlling quack grass and the general treatment of sandy loam soils. Abstracts of these addresses will be found after the proceedings of the Round-up Institute for this year.

Hon. Colon C. Lillie, of the State Dairy and Food Commission, was with the train for three days and gave a number of very helpful addresses.

Governor Fred M. Warner who has always taken great interest in farmers' institutes, and particularly in the institute trains, accompanied the train for four days and spoke at each place upon, "The Dairy Interests of Michigan," placing particular stress upon the importance of dairying both from the standpoint of profit and from the benefit of dairy cows in maintaining the fertility of the soil.

THE COST OF FARMERS' INSTITUTES.

During the past two years the amount appropriated for farmers' institutes has been $8,500. In nearly all of the neighboring states the amount available for farmers' institutes is two or three times this sum and yet very few, if any of them, have taken up work along all of the lines that have been introduced into Michigan.

A report recently issued by the U. S. Department of Agriculture gives a summary of the Farmers' Institute work in the different states during the year ending June 30th, 1909, and below is a summary of the results obtained in some of the neighboring states:

Institutes in other States.

State.	Cost.	Number sessions.	Attendance.	Institute training. No. days.	Normal institute. No. days.	Round-up institute. No. sessions.
Indiana	$19,000	1,162	215,211	.....	.....	.....
Iowa	10,000	415	103,750	.....	.....	.....
Michigan	8,823	1,163	167,563	11	7	12
Nebraska	14,795	500	36,623	.....	.....	.....
New York	28,000	1,020	133,787	2	11	*33
Ohio	22,000	1,765	440,500	7	2	5
Pennsylvania	20,000	983	156,652	.....	9	.....
West Virginia	9,249	356	19,424	6	.....	.....
Wisconsin	20,000	705	93,090	.....	.....	11

*Institute schools.

From the above it will be seen that no other state, except Ohio, has conducted institute trains, and normal institutes in addition to the round-up institutes. In Michigan a round-up institute report of 300 pages, with an edition of 12,500 copies has been printed and distributed. Very few of the other states have done this.

Without making any allowance for the cost of the normal institute, institute trains, for the printing of the institute report, superintendance and office expenses, the average cost per session of institutes in Michigan has been $7.59.

Cost per Session and per Capita.

State.	Per session.	Per capita of attendance.
Indiana	$16 35	$ .088
Iowa	24 10	.096
Michigan	7 59	.05
Nebraska	29 60	.17
New York	27 45	.21
Ohio	12 46	.05
Pennsylvania	20 35	.127
West Virginia	25 98	.49
Wisconsin	28 37	.222
Average for U. S.	$22 42	$ .18

In some states the cost per session runs from $60.00 to $75.00, while the average for the entire United States is $22.42.

An examination of the above tables should convince anyone that Michigan Farmers' Institutes compare very favorably with those in other states so far as the number of sessions, total and average attendance and the cost per session are concerned and, besides this, good results have been secured from the normal and round-up institutes, the institute trains, and the institute report has been widely distributed. In no other state have all of these phases of institute work received attention and, with few exceptions, not more than one of these lines of work has been taken up.

LARGER APPROPRIATIONS NECESSARY.

In none of the neighboring states is the appropriation as small as that available in Michigan and in most of them it runs from two to three times as large. During the last year no attempt was made to secure requests for institutes as it was felt that with the limited appropriation there was no occasion for doing so. A large number of requests, however, were received which it was necessary to decline, although it was very evident that the interest was such as would make it possible to hold successful meetings. Although the table indicates that the average expense of institutes in Michigan is $7.59 per session, in reality it has been possible to hold one-day institutes for which the call is greatest at an expense of not to exceed $2.00 per session, or $5.00 to $6.00 per institute of three sessions. It should be noted that the expense of the round-up institute including the printing and mailing of the institute report is about $1,600.00, while the average expense for the two-day institutes is not far from $25.00, or $5.00 per session.

INSTITUTE SCHOOLS.

In many of the counties where institutes have been held for twenty or more years there is undoubtedly a demand for the holding of institute schools, that is, for the holding of institutes which shall be conducted much the same as college classes. For several years I have been hoping

that funds would be provided so that it would be possible to hold such institute schools, but with the limited amount available and considering the calls that have been received for the holding of a larger number of one-day institutes and for the running of institute trains, it has been felt that far more good would be done and to a greater number of persons in that way, as the institute school at which three or four instructors are in attendance is far more expensive than the ordinary farmers' institute.

Respectfully submitted,

L. R. TAFT,

Supt. Farmers' Institutes.

East Lansing, June 30, 1910.

REPORT OF THE STATE INSPECTOR OF NURSERIES AND ORCHARDS.

Hon. J. L. Snyder, President State Board of Agriculture:

Sir: I have to report a considerable increase in the amount of work that has come to this department during the year. This has been due in part to the fact that the San Jose scale and peach yellows have gradually spread into sections in which they had not hitherto been found, and where, as the farmers and fruit growers were not familiar with their appearance, it became necessary to devote more time both to tracing out infested, or infected areas, and in securing the appointment of competent local inspectors, than had been required in previous years.

INSPECTION OF NURSERIES.

The work of examining the trees and plants growing in Michigan nurseries was carried on in much the same way as in previous years. In order to make sure that the stock could not become infested between the time it was inspected and the date of digging, the work in nurseries in dangerous proximity to known sources of contagion was delayed until the latter part of September, but much of the work was done during the month of August and early September.

A marked improvement in most of the nurseries was noticeable and the danger of contagion has been lessened by increased attention to cleaning up in the nurseries in the way of destroying seedling and other trees which might become infested, as well as spraying the nursery stock itself. As a result of this care, the nursery trees were in noticeably better condition than in previous years and the amount of "cleaning up" required at the time of digging was considerably lessened.

The trees were unusually free from crown gall, root aphis, woolly aphis and other insects, which in some years have been found in several of the nurseries. In fact about the only dangerous insect found in any nursery during the year was the San Jose scale, and its presence was less frequent than in previous years. As is required by law, the in-

fested trees were destroyed and the others in the vicinity were fumigated with hydrocyanic acid gas before they were sold.

Only a comparatively few of the nurseries in Michigan grow a general line of nursery stock, most of them confining themselves to growing peach trees, small fruits and ornamental shrubs, and purchase most of their cherry, plum, pear and apple trees from firms which make a specialty of growing them. Not only do these fruits require special soil conditions, but ordinarily the very best of care is needed, so that the average nurseryman is wise in thus purchasing his stock of the above classes of fruit trees rather than try to grow it himself.

With the average conditions that prevail, not 10 per cent of the trees started will be merchantable, while the specialist may obtain 75 to 90, or even more.

INSPECTION OF IMPORTED STOCK.

During the winter months careful watch was kept upon the shipments of imported seedling stocks from Europe. Notice was received from the nurseries and also from the Bureau of Entomology, U. S. Department of Agriculture, and the Bureau of Horticulture of the New York State Department of Agriculture. This work was a continuation of that started one year ago when it was found that winter nests of the brown-tail moth, as well as egg clusters of the gypsy moth were upon European nursery stock shipped to the United States.

A very noticeable improvement was found in the shipments received during the past winter as although a few nests containing living larvae were found, the total number was but little more than ten per cent as large as during the previous year and, in a majority of cases, the larvae were dead. Whether this was the result of dipping or fumigating the stock before it was packed, or from heating of the nursery stock itself which might have occurred in shipment, could not be determined. That the infestation had been much more serious was evident from the fact that a considerable number of the seedlings had portions of nests still attached to them.

With the steps that have been taken to examine nursery stock as it is imported, it is hoped that the Michigan nurseries are still free from this insect, especially as no indications of its presence were observed during the year. Although egg clusters of the gypsy moth have been observed upon the shipments of nursery stock received from Europe, nothing of the kind has been found upon Michigan shipments.

Dangerous as is the brown-tail moth, there is even more reason for fearing the appearance of the gypsy moth, as, while the attacks of the brown-tail moth are very largely confined to our common fruit trees and oaks, the gypsy moth is found upon practically all trees and shrubs and a single stripping of the leaves proves fatal to evergreen trees and quite injurious to others.

INSPECTION OF ORCHARDS.

During the year a large number of visits were made to orchards of which complaints were made as presumably infested with dangerous insects or diseases. Arrangements were made for the proper treatment and in sections where the San Jose scale or peach yellows was found,

the appointment of orchard inspectors by the township board was effected. Especial attention was paid in sections along the border line of regions where the San Jose scale and peach yellows are present with the idea of heading off their spread. Neither of these has appeared north of Mason county and, while there is no reason to think that the yellows in particular has been limited in its spread by climatic conditions, it has been found particularly helpful to work along the "firing line" in order to prevent its spread into new sections and at the same time inform the fruit growers of the nature and danger from this trouble.

The San Jose scale is becoming quite generally distributed in the southwestern and southeastern corners of the state and is found here and there throughout the southern central portion. The increased attention to fruit growing, and to apple growing in particular, has led to the more general spraying of the orchards and where the work has been taken up in time no difficulty has been found in controlling this insect.

LICENSING THE NURSERIES.

The Michigan nurserymen and persons who are engaged in selling nursery stock that has been grown by other parties, as well as nurseries in other states which have agents in Michigan, very generally complied with the law requiring them to take out a license. The following is a list of the licenses issued for the year ending July 31, 1910.

LIST OF LICENSED MICHIGAN NURSERIES, 1909-10.

Alferink, Albert, Holland, No. 8.
Allen Brothers, Paw Paw.
Ayers, C. J., Adrian.
Baldwin, O. A. D., Bridgman.
Blake, William, Niles, No. 6.
Boehringer Brothers, 235 Park Ave., Bay City.
Bragg, L. G. & Co., Kalamazoo.
Celery City Nurseries, Kalamazoo.
Central Nursery & Floral Co., Kalamazoo.
Clark, D. H., Holland.
Cole, Levant, Battle Creek.
Collins, W. E. Fennville.
Coloma Nursery Co., Coloma.
Coryell, R. J., Birmingham.
Cukerski, W. L., So. Wealthy Ave., Grand Rapids.
Culver, O. B., Colon.
Cutler & Downing Company, Benton Harbor.
Daly, T. W. Watervliet, No. 3.
Dean, Geo. N., Shelbyville.
Dunham, E. W., Baroda.
Dressel, G. L., Frankfort.
Drought, William, Douglas.
Dutton, Charles S., Holland.
Essig, W. W. & Co., Suite 20, Jones Bldg., Detroit.
Ferrand, E. & Son, Vinewood Ave., Detroit.

Fisher, Guyon, Fennville, No. 1.
Flansburgh, C. N. & Son, Jackson, No. 7.
Flansburgh & Potter Co., Leslie.
Genesee County Nurseries, Flint.
Gobiel, Patrick, St. Joseph.
Greening Nursery Co., Monroe.
Gustin, C. F., Adrian.
Haines, J. W., Eaton Rapids.
Hamilton, A. & Son, Bangor.
Havekost, G. H., Monroe.
Hart Nursery, Hart.
Hawley, Geo. A., Hart.
Hawley, H. E., South Haven.
Helmer Farm Nursery, Battle Creek, No. 6.
Hodges, Ezra & Son, Mayville.
Ilgenfritz, Chas. A., Monroe.
Ilgenfritz, I. E. Sons Co., Monroe.
Jeffrey, James, Sr., Kalamazoo.
Jones & Ebelink, Holland.
Kalamazoo Nurseries, Kalamazoo.
Keeler, Edwin J., Paynesville.
Kellogg Co., R. M., Three Rivers.
Knight & Son, David, Sawyer.
Marvin, O. F., Holton.
Maudlin Nursery, The E., Bridgman.
Michigan Nursery Co., Monroe.
Miller, Abner, Fennville.
Moore, Bert R., Eau Claire.
Morrill, R., Benton Harbor.
Munson, W. K. & Son, Grand Rapids.
Negaunee Nurseries & Greenhouses, Negaunee.
Nelson, J. A. & Son, Paw Paw.
Newell, Reuben, Chandler Ave., Highland Park.
Pier, Frank D., Leslie.
Pilkinton, S. H., Portland.
Pontiac Nursery Co., 240 Woodward Ave., Detroit.
Powers, Charles, Douglas.
Prudential Nursery Co., Kalamazoo.
Retz, Mathias, Riverside.
Schild, H. J., Ionia.
Sheldon, Asa G., Paw Paw.
Singer, W. H., Lapeer.
Smith, E. J., Cheboygan.
Smith, Henry, Grand Rapids.
Speyers, Chas. M., Willis.
Spielman Brothers, Adrian.
Starr, George E., Royal Oak.
Stephens & Allain, South Haven.
Stoddard, L. H., Kalamazoo, No. 12.
Stone, John & Son, Hillsdale.
Sweet, L. H., Carsonville.

Taplin, Stephen, W. Fort St., Detroit.
Tossy, L. F., Alter Road & Kercheval Ave., Detroit.
Utter, Jay J., Bravo.
West Michigan Nurseries, Benton Harbor.
Weston, A. R. & Co., Bridgman.
Whitten, C. E., Bridgman.
Wildemere Gardens, Highland Park.
Wise, Ralp, Plainwell, R. D.
Wolverine Co-operative Nursery Co., Paw Paw.

MICHIGAN NURSERY DEALERS, LICENSED IN 1909-10.

Augustine, L. D., St. Joseph.
Beattie, Thomas, 185 Josephine Ave., Detroit.
Berrydale Experiment Gardens, Holland No. 1.
Bowser, F. L., Shepherd.
Crowley, Milner & Co., Detroit.
Davison Nursery Co., Davison.
Dow, H. C., Kibbie.
Freyling & Mendels, 891 Wealthy Ave., Grand Rapids.
Grand Rapids Nursery Co., Monroe St., Grand Rapids.
Herpolsheimer Company, Grand Rapids.
Heyboer, A., 1406 Division St., Grand Rapids.
Hibbler, Edwin B., 119 Columbia St., E., Detroit.
Hudson, J. L. Co., Detroit.
Hunter & Hunter, Detroit.
Husted, N. P. & Co., Lowell.
Kingsbury, Lathrop, Muskegon.
Knapp, W. F., Monroe.
Knox, S. H. & Company, Buffalo, N. Y.
Lamson & Rood, Covert.
Lock, Daniel, Union Pier.
Lohrman Seed Company, 73 Gratiot Ave., Detroit.
McCormick Nursery Co., Monroe.
Merrill, W. F., South Haven.
Nash, C. C., Kalamazoo.
Pearson, D. S. & Co., Grand Rapids.
Radewald, O., Niles.
Sodus Nursery Co., Sodus.
Sonter, Geo. H., Holland.
Strittmatter, Adolph, 1054 Gratiot Ave., Detroit.
Trankla, Chas. & Co., Grand Rapids.
Walther's Department Store, Bay City.
Webb, D. S. & Co., Fife Lake.
Westgate Nursery Co., The H. L., Monroe.
Winkworth, R. M., 80 Farrar St., Detroit.

FOREIGN NURSERY DEALERS, LICENSED IN MICHIGAN IN 1909-10.

Allen Nursery Co., Rochester, N. Y.
Bogue, Nelson, Batavia, N. Y.
Brown Brothers Co., Rochester, N. Y.
Bryant Brothers, Dansville, N. Y.
Bryant, Arthur & Son, Princeton, Illinois.

Cartwright, I. D., 22 St. Clair Bldg., Toledo, O.
Charlton Nursery Co., Rochester, N. Y.
Chase Brothers' Co., Rochester, N. Y.
Chase, Charles H., Rochester, N. Y.
Chase Nurseries, The, Geneva, N. Y.
Costich Co., G. A., Rochester, N. Y.
Darling, Irvin C., Son & Co., 1414 E. 88th St., Cleveland, O.
Davis Nursery Co., Franklin, Baltimore & Paca Sts. Baltimore, Md.
Dreer, Henry A., 714 Chestnut St., Philadelphia.
Fairview Nurseries, Rochester, N. Y.
Farmers' Nursery Co., Troy, O.
First National Nurseries, Rochester, N. Y.
Foster & Griffith, Fredonia, N. Y.
Fremont Nursery, The, Fremont, Ohio.
Harman, M. H. Co., Geneva, New York.
Hawks Nursery Co., Rochester, N. Y.
Henby, J. K. & Son, Greenfield, Ind.
Herrick Seed Co., Rochester, N. Y.
Home Nursery Co., Bloomington, Ill.
Hooker, Wyman & Co., Rochester, N. Y.
Jewell Nursery Co., Lake City, Minn.
Knight & Bostwick, Newark, N. Y.
Masters, G. A., Schiller Bldg., Chicago, Ill.
McGlennon & Kirby, Rochester, N. Y.
Miami Valley Nurseries, Phoneton, Ohio.
North Jersey Nurseries, Newark, N. J.
Pennsylvania Nursery Co., Girard, Penn.
Perry Nursery Co., Rochester, N. Y.
Portland Nursery Co., Portland, Ind.
Ringler Rose Company, 1112 Rector Bldg., Chicago, Ill.
Sidney Nurseries, The, Sidney, Ohio.
Simpson, H. M. & Son, Vincennes, Ind.
Spring Hill Nurseries, Phoneton, Ohio.
Standard Nursery Co., Rochester, N. Y.
Stark Brothers' Nurseries and Orchards Co., Louisiana, Mo.
Swain Nelson Sons Co., 941 Marquette Bldg., Chicago, Ill.
Van Dusen Nurseries, The, Geneva, N. Y.
Western New York Nursery Co., Rochester, N. Y.
Whitney, G. W. & Co., Dansville, N. Y.
Willett & Wheelock, No. Collins, N. Y.

The taking out of a license by the above nurseries gives each of them the right to put agents at work, either on a salary or a commission, canvassing for the sale of nursery stock in Michigan. While some of the smaller agents have no agents and others only one or two, several of the larger firms have two or three hundred agents working for them so that really the number of persons selling nursery stock in Michigan is much larger than appears in the above list.

Respectfully submitted,

L. R. TAFT,
State Inspector of Nurseries and Orchards.

TWENTY-THIRD ANNUAL REPORT

OF THE

EXPERIMENT STATION

OF THE

MICHIGAN AGRICULTURAL COLLEGE

UNDER THE HATCH ACT

FOR THE

YEAR ENDING JUNE 30, 1910.

For members and organization of the State Board of Agriculture in charge of the Station and list of officers, see page 13 of this volume.

REPORT OF THE DIRECTOR OF THE EXPERIMENT STATION.

To President J. L. Snyder:

During the past year the following changes have been made in the Experiment Station organization, viz: The supervision of the South Haven Sub-station was placed under the management of H. J. Eustace, Horticulturist. Professor V. M. Shoesmith was appointed Farm Crops Experimenter and assumed the duties of this office about the middle of February, 1910. Professor J. Fred Baker was made a member of the Station Council during the latter part of the year occupying the position of Forester. Dr. L. M. Hurt, Veterinarian of the Advisory and Assistant Staff, resigned December 31st, 1909, and the work of his office has since been handled by Dr. Ward Giltner of the Bacteriological Department. Other changes occurring within the various departments are given in the reports from the same.

During the year the following publications have been issued by the Experiment Station, viz:

Bulletin No. 256—Fertilizer Analyses by A. J. Patten and C. B. Collingwood.

Bulletin No. 257—Rearing Calves on Skim-milk and Supplementary Feed by H. W. Norton, Jr.

Bulletin No. 258—Insects of Field Crops by R. H. Pettit.

Bulletin No. 259—Bean Production by W. F. Raven.

Bulletin No. 260—Seeds of Michigan Weeds by Dr. W. J. Beal.

Bulletin No. 261—Baby Beef Production by H. W. Norton, Jr.

Special Bulletin No. 50—Grand Traverse Disease or Lake Shore Disease by C. D. Smith.

Special Bulletin No. 51—Spray and Practice Outline for Fruit Growers by H. J. Eustace and R. H. Pettit.

Special Bulletin No. 52—Corn Production in the Upper Peninsula by L. M. Geismar.

Special Bulletin No. 53—Grasshoppers and Their Control by L. M. Geismar.

Technical Bulletin No. 2—Keeping Qualities of Butter by Otto Rahn, C. W. Brown and L. M. Smith.

Technical Bulletin No. 3—Studies of Agglutination Reaction in Hog Cholera During the Process of Serum Production by Dr. Ward Giltner.

Technical Bulletin No. 4—Organic Nitrogenous Compounds in Peat Soils by Dr. S. L. Jodidi.

Technical Bulletin No. 5—The Usefulness of Curves in the Interpretation of Microbial and Biochemical Processes by Otto Rahn.

Circular No. 6—Hog Cholera Serum by Bacteriological Laboratory.

Circular No. 7—Lactic Cultures for Dairy Purposes by Bacteriological Laboratory.

Circular No. 8—Tuberculosis by Bacteriological Laboratory.

Circular No. 9—Vinegar and Its Making by Bacteriological Laboratory.

Press Bulletin 22—The Tussock Moth by R. H. Pettit.

Press Bulletin 23—Directions for Spraying by H. J. Eustace and R. H. Pettit.

Press Bulletin 24—Bean Production by R. S. Shaw.

The Animal Husbandry Department, supported exclusively from funds other than the Experiment Station, is continuing useful lines of investigation work. The third successive year's work has been completed in which experiments have been conducted with sheep to determine the effect of succulent factors in the ration on fecundity, prolificacy and meat, wool and milk production. To this department the Experiment Station is also indebted for the results reported in bulletins 257 and 261. The investigations of this department with swine will be given more attention during the coming year.

The Department of Farm and Horses, a part of the college organization, has given us the data for bulletin 254, a preliminary report on the Economic Wintering of Farm Work Horses. This work has been continued for two years since the issuance of the preliminary report and will be carried on until the subject has been exhaustively investigated. A three year accounting with the college farm comprising about 255 acres of tillable land has been about completed and the data and methods will soon be made public.

The Poultry Department, also a college organization, has completed three years' work investigating the comparative economic values of different types of poultry houses designed to meet the farmer's needs. This work will probably be continued for one more year before publishing results.

The Department of Farm Mechanics is still continuing a line of investigation relative to water systems for farm houses and farm buildings. The rapid evolution of power machinery suitable for various uses on the farm is opening up great possibilities relative to farm water supply, a factor having a direct bearing on the health and comfort of both man and animals.

During this year the Farm Department of the Experiment Station has benefited greatly through the use of college lands which have not hitherto been platted year after year for crop comparisons and tests of the effects of various fertilizers. The continued use of college farm lands will greatly facilitate the accomplishment of results in farm crops breeding and testing and tend to produce more reliable results than could be secured from a more restricted area platted over and over again year after year.

Hitherto the Forestry Department has had but a few acres available for nursery work near the college buildings. It is the plan at present to give up field No. 6 comprising 29 acres, just across the river, entirely to forest nursery work. It is hoped that this will permit of the development of experimental work which will be valuable in addition to economizing in time and labor and making this feature more readily available to the public and the student.

The bulletin mailing work has been placed in charge of Mrs. M. V.

Bogue and suitable quarters have been provided in the new agricultural building. The new plan and quarters greatly facilitate the ease and promptness with which bulletin issues are placed in the hands of the public.

REPORT OF THE BACTERIOLOGIST.

Director R. S. Shaw:

Dear Sir: Owing to the loyal and active support of my collaborators, I am able to point out development along the several lines of investigation in which we are interested.

SOIL INVESTIGATIONS.

Dr. Otto Rahn has been in direct charge of these investigations, and during the year, notwithstanding the demands made upon him by his responsibilities as a teacher, consuming nearly all of his time when college is in session, he has been able to outline a plan of action and institute much work. In coöperation with the divisions of soil physics, chemistry, and botany, the course of study has been well and definitely arranged. In accomplishing these results, he has been obliged to feel his way through preliminary researches.

The first of May, Mr. W. A. Wentworth was called by the station to assist him.

LACTIC ACID FORMATION IN MILK AND ITS INFLUENCE UPON TYPHOID GERMS.

Last year, I mentioned the undertaking of this problem by Zae Northrup, and the difficulties encountered in its solution. Since then, the problem has been attacked by different methods.

Much progress has been made with this investigation, and quite decisive results obtained. Miss Northrup hopes to have her studies ready for publication at an early date.

BUTTER INVESTIGATIONS.

Mr. C. W. Brown has been alone engaged upon this theme for the past year. The work represents the continuance of the investigations which have been reported in Tech. Bul. No. 1 by Wm. Sayer, Otto Rahn, and Bell Farrand, and in Tech. Bul. No. 2 by Otto Rahn, C. W. Brown, and L. M. Smith, both issued from this station.

Inasmuch as the butter which is furnishing a basis of study at the present time calls for further analyses and examinations in July and perhaps later, it will be impossible to formulate the results of the investigations as early as last year.

THE TUBERCULIN TESTING.

Purpose.—The past year, a plan has been inaugurated by this department to fight tuberculosis among the cattle and other domestic ani-

mals of the state. Believing that it is a struggle that will continue over many years, a plan that does not possess growth and at the same time, scope of action, must sooner or later become dormant through its own weight.

Plan.—Accordingly, the plan devised has been subjected to critical review by many men well acquainted with tuberculosis and the fight waged against it. The fundamental feature of this plan as conceived is education.

We aim to teach any bright young man who is able to master the technical feature of the work and to understand appreciatively the necessary available knowledge of the subject. In the work of instruction is given a thorough review of the salient features and a practical demonstration and actual practice in such phases of the subject as will yield to such treatment. After completing this portion of his course, he actually engages in conducting the tuberculin test under direct and skilled supervision. If he then gives satisfactory evidence of his proficiency, he is given a statement which certifies his ability to test. He is then considered capable of conducting the tuberculin test under the general supervision of this laboratory, the laboratory always reserving the right to interpret the results, and to reject the work of any man if he is thought undesirable.

Such young men are advised to exercise this privilege of testing only in their own community, because it is not hoped to prepare men to devote their entire time to testing, but rather to prepare young men who can test their own stock and help their neighbors out when requested. Errors easily creep into the test if a herd is unknown to the tester, accordingly, the plan seeks to have every tester acquainted with the animals he tests.

Besides the testing, the owners will constantly seek advice, instructions, and may wish help in disinfecting and inducing hygienic measures. If tuberculosis exists, the man who has done the testing and is especially interested in it, and further has the history of each animal, can follow such a herd through as many tests as may be necessary to eliminate the disease.

The plan does not contemplate official tests, or aim to meet the transient demands over the state. This policy is foreign to our scheme.

Discussion.—After stating the purpose of this work and the plan of execution, the reasons for fostering such a scheme may not be impertinent.

The spread and significance of this disease among cattle and swine cannot be disregarded. For support of this attitude, I refer the reader to Circular No. 8 of this report. Should only a part of what is set forth in this circular be true, it follows that every man who owns cattle and swine cannot or should not fail to be actively interested in this matter.

The stockman usually manifests his first interest in this subject through the personal interest in his own herd. He is not satisfied in his own mind whether this disease exists or not, and is fearful lest it may. To demonstrate its presence, he must resort to a tuberculin test.

This is a stumbling block. He, as a rule, would prefer to conduct the testing if it is within his power. Since it deals with technical matters with which he is more or less ignorant, he either seeks to learn the ap-

plication of the test for his own benefit or would like to secure someone in whom he has the greatest confidence at the least expense, for both confidence and expense are two very important factors in this work.

This is where the Department of Bacteriology and Hygiene has stepped in. It aims to furnish the essential facts regarding the disease and to teach the farmer to apply the test.

Another aspect of the case confronts us: Will this be regarded as veterinary practice by the law and by the veterinarians? There is no question that the well-trained veterinarians are the best equipped to apply the test and supervise herds having tuberculosis. Two obstacles, however, arise immediately to hinder progress.

There are about 600 veterinarians in the state and about 2,500,000 cattle. If the veterinarians gave up their entire time to the work, it would be a physical impossibility for them to test these animals once during the period of two years, say nothing of following up tuberculous herds. Therefore, it is out of the question to have well-trained veterinarians test cattle exclusively, however desirable it may be.

Neither the veterinarian nor the farmer, in eighty or more per cent of herds, can afford to submit to a fair compensation, which from the veterinarian's standpoint he may rightly ask, but which from the farmer's standpoint he cannot afford to pay. To illustrate, consider a herd of five cattle. If the veterinarian conducts the work properly, it will require practically all of his attention for two days, which, if he is a successful veterinarian, can not be less than ten dollars each day. The farmer cannot pay twenty dollars to have five cows tested, or, in other terms, four dollars per head.

Again, there are many veterinarians not familiar with the test, and some not familiar with the disease; consequently, a good discount should be made from the total number of veterinarians in the state.

This matter was presented at a representative body of veterinarians meeting in Saginaw last January. After presenting the matter, no objection was raised; however, there may have been those who said nothing but were not convinced. To such individuals, at any time when it is feasible, I should like to present an array of evidence which must convince the most skeptical. If not accepted, the veterinarians must appear in the light of opposing the fight against tuberculosis on professional grounds or see the uselessness of veterinarians attempting to conduct all tests. It is certainly to the credit of the veterinarians to recognize the situation as it exists and accept a broad, progressive interpretation. Many veterinarians have already taken a hand in the movement and are doing all they can to promote the struggle against this disease. A more generous spirit cannot be shown.

While there are features of the tuberculin test which would be best handled by veterinarians, it may be regarded largely as a mechanical test and be handled by any bright young man trained in the work. It makes it possible, therefore, for any bright young man to secure the training and the knowledge of the disease such as will enable him to ascertain whether the disease exists in his herd, or the herds of his neighbors, to follow up this disease in an approved manner, to disinfect, to institute sanitary improvements, in short to supervise intelli-

gently the disease under the general recommendations of this laboratory. There is an advantage which accrues to this scheme.

If a tester knows his animals, can follow the temperatures of each year by year, can learn the peculiarities of each animal and the history of each, he will be in far better position to get at the truth of the situation than a man who accidentally visits the herd for a test, or has tested so many animals that the identity of the individual is lost, or attends to the herd only when called.

One of the features which we consider very valuable to us, is this community integer, this limitation of a tester, this singleness of purpose, and permanency of the individual as a member of the community. We hope that from this there will be a slow, progressive development which will be healthful and in the period of *years* will completely control this disease.

We are working and aiming to accomplish for the farmer that which will be the best for him, and do not seek for momentary applause or endeavor to favor a chosen few at the expense of the many.

This proposition is in the hands of the farmer and he must sooner or later deal with it in a very real and material manner, unless some remedy is found which will either counteract this disease as a vaccine or cure it when once under way.

REPORT ON INSTRUCTION IN TUBERCULOSIS AND TUBERCULIN TESTS, FOR YEAR 1909-10.

Lectures and demonstrations were conducted through "Dairy Week." One lecture was given each day from three to four, during the week, covering general policies, general discussion of the disease, and general instructions. The work was divided about as follows:

Monday, 3 to 4, the purposes of the course were stated, and the plan of operation was described.

Tuesday, 3 to 4, extent of human, bovine, and porcine tuberculosis was taken up and discussed.

Wednesday, 3 to 4, a discussion of the disease in its various forms —the cause of the disease, immunity, and susceptibility were considered.

Thursday, 3 to 4, a discussion of methods of handling tuberculosis in the various states and countries was taken up.

Friday, 3 to 4, was given over to the tuberculin test—preparation of tuberculin, its curative value, its diagnostic value, and its employment in the test, and the reactions.

Demonstrations were carried out by Dr. Giltner, as follows:

Monday, 4 to 6, study of specimens.

Tuesday, 4 to 6, physical demonstrations.

Wednesday, 4 to 6, stable hygiene.

Thursday, 4 to 6, disinfection.

Friday, 4 to 6, preparation for tuberculin test.

Monday and Tuesday of the following week were given over to test

ing the herd, and post-mortem examinations. This plan proved very satisfactory, perhaps with one exception: The men were not fully satisfied to have a vacation Saturday afternoon and Sunday, awaiting the test.

It would be better if the test could in some way be consolidated within the week's work.

The following letter was sent to the veterinarians of the state:

MICHIGAN AGRICULTURAL COLLEGE
LABORATORY OF
BACTERIOLOGY AND HYGIENE.

Dear Doctor: Tuberculosis has become such a big problem that it is reaching beyond the bounds of any profession and demanding the attention of all who can offer assistance in any way. The work in any state has not exceeded two or three per cent of the cattle of the state, and usually it is confined to less than one per cent of the cattle.

It is impossible for professional men to cope with it. There are not enough veterinarians in the state, even if all their time were given to testing, to cover half of the cattle of the state just once in a year; in short, it would take from 1,000 to 2,000 veterinarians to test all of the cattle of the state in one year's time, devoting every week in the year to the work. There are less than 600 veterinarians in the state.

No progress has been made in eliminating this disease from our midst. Here and there has been a test, but it is like removing one small-pox patient from a community having an epidemic and leaving thirty behind.

According to the best figures available, about 3 per cent of all cattle, 6 per cent to 9 per cent of all dairy cattle, and 20 per cent to 30 per cent of all thoroughbred cattle have tuberculosis.

The tuberculin test, according to the Bureau of Animal Industry, is correct in 98.81 per cent of cattle tested. Is there any diagnostic agent equal to it in efficiency?

It is largely a mechanical test, and can be applied intelligently by any bright man who has been trained and to whom assistance can be given in interpretation of the same and proper supervision rendered.

Our plan is to select bright young men representing groups of farmers who may wish to test their animals and train them in the disease of tuberculosis and its significance; in disinfectants and disinfection; also give them actual experience in testing. These young men will be able to go back and watch over a certain number of herds, testing and advising until the disease is cleaned up in the herds. If it is possible for veterinarians to do this work, it is advised because of their special professional training.

This laboratory will furnish the tuberculin for cost of carriage only, on condition that the test will be made according to our directions, and the full report of the test returned for our review and interpretation. Should any veterinarian desire to take part in or be present at the test conducted at the college, March 7th and 8th, he will be welcomed. The lecture and demonstrations will occur during "Dairy Week," Feb. 28th to March 5th.

You as an expert will doubtless be called upon by farmers who have large herds and can well afford expert testing to assist in this movement.

It will necessarily be slow in getting started, but all must cooperate in this fight against this disease which appears to be spreading rapidly among cattle.

This matter was presented to the veterinarians of the state, at their annual meeting, and it appeared to meet with their hearty approval. There was not an adverse criticism uttered.

Will you not give this movement your moral support, and help wherever it is possible to make it a slow, persistent, progressive method of eradication of tuberculosis among cattle of the state?

Very respectfully,

CHARLES E. MARSHALL.

East Lansing, Mich.

A very similar letter was sent to many stockmen of the state, as well as those four-year graduates residing on farms, and those who have completed the two-year short course.

MICHIGAN AGRICULTURAL COLLEGE
LABORATORY OF
BACTERIOLOGY AND HYGIENE.

Dear Sir: Tuberculosis appears to be gaining ground among the cattle of the state. If this is true, every effort should be made by the farmer to counteract its progress by ascertaining whether the disease exists in his herd, or not.

It is impossible, in many cases, for farmers to depend upon professional assistance in this matter; in fact, the disease is so extensive, and the problems have become so important that in order to eradicate it, some plan must be devised by which the farmer himself will be able to cope with its ravages.

There are not enough veterinarians in the state, even if all their time were given to testing, to cover half of the cattle of the state just once in a year. Wherever veterinarians may be secured to conduct or supervise tests, this is advised.

Thus far, no progress has been made in eliminating this disease from our midst. Here and there has been a test, but it is like removing one small-pox patient from a community having an epidemic, and leaving thirty behind.

According to the best figures available, about 3 per cent of all cattle, 6 per cent to 9 per cent of all dairy cattle, and 20 per cent to 30 per cent of thoroughbred cattle have tuberculosis.

The tuberculin test is the only reliable means of ascertaining whether the disease exists or not. It has been established by the figures of the Bureau of Animal Industry that the efficiency of this tuberculin test is 98.81 per cent. No other diagnostic is equal to it.

It is largely a mechanical test, and can be applied intelligently by any bright young man who has been trained.

Our plan is to select bright young men to represent groups of farmers, having herds, who may wish to test their animals. These young men will be able to secure such training as is necessary in the disease of tuberculosis, and its significance; in the actual testing of cattle; in preparation of disinfectants and in methods of disinfection, and in any

other matters such as may be helpful in the management of the disease. These young men will be able to go back and watch over a limited number of herds, testing and advising until the disease may be cleaned up.

This laboratory will furnish tuberculin for cost of carriage, on condition that the test will be made according to its directions and the full report of the test returned for its review and interpretation.

The subject of tuberculosis will be treated this year by demonstrations and lectures during the "Dairy Week," Feb. 28th to March 5th. The following week, Monday and Tuesday, March 7th and 8th, will be devoted to actual testing of animals. Wednesday may be devoted to the interpretation of results. During this time, it is hoped sufficient training may be gained by those taking the work to enable them to conduct tests under the supervision of the laboratory.

Very respectfully,

CHARLES E. MARSHALL.

East Lansing, Mich.

Forty-four availed themselves of the opportunity offered by the complete course, and many others took the lecture work only.

The following certified statement is given each man satisfactorily completing all the work offered in tuberculosis.

MICHIGAN AGRICULTURAL COLLEGE
LABORATORY OF
BACTERIOLOGY AND HYGIENE.

To whom this may interest:

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Our plan is to select bright young men to represent groups of farmers, having herds, who may wish to test their animals. These young men

will be able to secure such training as is necessary in regard to the disease of tuberculosis, and its significance; in the actual testing of cattle; in preparation of disinfectants and in methods of disinfection, and in any other matters such as may be helpful in the management of the disease. These young men will be able to go back and watch over a limited number of herds, testing and advising under the direction of this laboratory until the disease may be cleaned up.

This laboratory will furnish tuberculin for cost of carriage, on condition that the test will be made according to its directions and the full report of the test returned for its review and interpretation.

The request for tuberculin must be accompanied by a statement of the number of animals to be tested and the signature and address of the owner of the herd.

This laboratory will send tuberculin only to its field representative to be used by him in person.

The testing must be done in person by the field representative of this laboratory and all disinfecting should be under his personal direction.

Any questions concerning tuberculosis or the tuberculin test will be gladly answered through our field representative; and any questions concerning the training or acceptability of the field representative, the laboratory will be glad to take up directly with anyone who may wish to inquire.

This laboratory assumes no responsibility for financial arrangements entered into by the field representative, but in case of excessive charges or complaints, this laboratory would like to be informed. The field representative receives no compensation from this laboratory.

This certifies that.....has taken the required course covering *tuberculosis* and the *tuberculin test* and is prepared to test, to disinfect, and advise under the supervision of this laboratory.

Signed.....

East Lansing, Michigan.

He is also furnished with the suggestions and directions which follow:

MICHIGAN AGRICULTURAL COLLEGE
LABORATORY OF
BACTERIOLOGY AND HYGIENE.

TUBERCULOSIS AND THE TUBERCULIN TEST.

Suggestions and Directions to Field Representatives.

1. Be absolutely honest, frank and conscientious. Any departure from this policy means disaster sooner or later.

2. This laboratory is ready to assist you in every way possible, unless it is evident that you are not faithful in the performance of your duty, when it reserves the right to cut off all relations and support.

3. Do not try to convince farmers of the necessity of the test and the importance of tuberculosis; let them convince themselves. You are ready to assist if requested.

4. The farmer, if he wishes the test applied, should understand that he must give intelligent direction to the elimination of the disease, if detected, and must disinfect and correct sanitary conditions if necessary.

5. No fixed regulations can be prescribed regarding the method or system employed for handling tuberculous cattle, other than absolutely forbidding "underhanded" schemes. The work may be done unheralded and quietly, but no sale of tuberculous animals to unsuspecting parties will be tolerated. Any violation of this procedure should be reported to the laboratory at once.

A circular will be prepared giving many facts. Copies will be sent you for distribution among your neighbors who may be interested in tuberculosis and the tuberculin test.

6. The test must be conducted by the field representative in person and according to the instructions received at this laboratory. The record sheet indicates the number of temperatures to be taken before and after injection and also the time they should be taken. Follow the record sheet explicitly. Inject at the time indicated, describe each animal carefully by name, breed, etc., and give the weights as nearly as possible.

7. Do not go out of your community to test, that is, into strange communities, and do not undertake to test more herds than you can follow in detail. You should be able to identify every animal tested by you. If testing is done outside of your own community, the laboratory should be acquainted with the facts.

8. Read temperatures very carefully, and record exactly the readings made even to the smallest fraction possible. Make every record the subject of painstaking care and study. Do not let a misleading statement or word creep in if possible.

9. Make reports to the laboratory as soon after the test as possible.

10. Certify that the records are correct to the best of your knowledge.

Signed.....

East Lansing, Michigan.

From March 1st to July 1st, 383 cattle have been tested.

Dr. Giltner has contributed some work with hogs which were running with tuberculous cattle. The work is limited in various ways, but the results are well worthy of record. Inasmuch as this was only incidental to other duties and investigations and will not be continued it has been thought pertinent to insert it at this point in this report.

THE TRANSMISSION OF TUBERCULOSIS BY REACTING BUT APPARENTLY HEALTHY COWS.

The danger in the tuberculin reacting but apparently healthy cows has been pointed out by Schroeder and Cotton.[1] We believe with them that the bacteria leave the diseased individual most commonly via the digestive tract but it may be that the percentage of cases in which the feces and milk of reacting cows are infective can not be safely based upon their experiments.

Schroeder[2] says: "Among 12 apparently healthy cows known to be tuberculous only because they had been tested with the tuberculin test, microscopic examination revealed that 5, or 41 per cent, were passing feces infected with tubercle bacilli." "Among 13 cows, of which it was known that they had been affected with tuberculosis, eighteen months or more, the microscopic examination of feces revealed that 11, or 84.6 per cent were passing tubercle bacilli per rectum. These cows, judged by their general appearance, were in much better condition than the cows in many dairy herds; they certainly did not look like sick animals."

Mohler and Washburn[3] state that: "When hogs were fed on tuberculous milk for only three days the post-mortem examination held one hundred and seven days later showed that 83.3 per cent of the animals had tuberculosis. When hogs received tuberculous milk for thirty days and were allowed to live fifty days longer, 100 per cent of the animals had developed generalized tuberculosis." They also record that,—"tuberculin-tested hogs were placed in isolated pens where a few shovelfuls of such feces (from tuberculous cattle) were thrown daily while the hogs were fed upon other food which was free from tubercle bacilli. The result was the infection of 25 per cent of the first lot of hogs and 100 per cent of the second lot that was exposed." The tuberculous cattle were apparently healthy.

In sanitary control work it must be assumed that all reactors are dangerous as spreading the disease by infected feces or milk since a considerable percentage have been proven to do so. The following experiments are of interest in that they fail to show any danger from apparently healthy reactors.

Two tuberculous cows were kept in our laboratory stalls where we are constantly using large numbers of pigs. It was thought advisable to test the pathogenicity of the excreta of these two cows by intimate cohabitation with swine.

Expt. No. 1. Rosa Flint II, a two year old Angus. Oct. 6, '09, aborted a 5 months' fetus. She was in excellent condition.

The tuberculin test, Apr. 30, 1909, resulted as follows:

	6 a. m.	8. a. m.	10 a. m.	12 m.	2 p. m.	4 p. m.	6 p. m.
Before injection	.....	101.9	101.5	101.5	101.5	100.9	101.
After injection	102.1	104.6	104.6	105.5	105.7	105.8	105.6

Her dam, Rosa Flint I, was tuberculous. She suckled her dam.

Rosa Flint II was brought to our laboratory Oct. 10, 1909; placed in a disinfected stall, and treated for after-effects of abortion.

Oct. 13, 1909, placed Expt. pigs 237 and 270 in stall with Rosa Flint II. These pigs weighed about 50 pounds each and were not very thrifty. Dec. 1, 1909, these two pigs were placed in stall with tuberculous cow Mabel (See Expt. 2) where they remained several days.

Dec. 21, 1909, or 69 days after exposure, Expt. pigs 237 and 270 were

slaughtered and a very careful examination failed to reveal any lesions of tuberculosis.

They were fed from a shallow pan on the floor and made very good gains.

Dec. 4, 1909, a guinea pig was inoculated, subcutem with 2 cc. of a dense bouillon suspension of feces from Rosa Flint II.

Dec. 16, 1909, or 12 days after inoculation, guinea pig died. The liver showed multiple necrotic foci containing colon-like bacteria, but no evidence of tuberculous infection could be found.

Smears from the feces of Rosa Flint II failed to show presence of acid-fast bacteria.

Dec. 18, 1909, a guinea pig was inoculated subcutem with a portion of expectorated muco-purulent matter found in feed box of Rosa Flint II.

Jan. 20, 1910, or 33 days after inoculation, guinea pig died with symptoms and lesions shown by numerous others in laboratory. No evidence of tuberculous infection could be found.

Expt. No. 2. Mabel, a three years old Short Horn heifer, calved normally Oct. 6, 1909. She was from a tuberculous dam but had been raised on skimmed milk.

The tuberculin test on Mabel, Apr. 30, 1909 resulted as follows:

	6 a. m.	8 a. m.	10 a. m.	12 m.	2 p. m.	4 p. m.	6 p. m.
Before injection	.....	102.2	100.4	101.3	101.7	101.7	101.9
After injection	103.2	105.	104.5	104.7	105.2	105.3	105.6

Oct. 13, 1909, Mabel was placed in disinfected stall at laboratory together with Expt. pigs 255 and 193 weighing about 50 lbs. each, and not very thrifty. Dec. 18, 1909, or 66 days after exposure these pigs were castrated and removed from infected stall. Jan. 3, 1910, or 82 days after exposure, Expt. pig 255 was slaughtered and a careful examination failed to reveal any tuberculous infection.

Jan. 11, 1910, or 90 days after exposure, Expt. pig 193 was slaughtered and no lesions of tuberculosis were found.

These pigs had grown well.

Dec. 4, 1909, a guinea pig was inoculated subcutem with 2 cc. of a dense bouillon suspension of feces from Mabel.

Dec. 19, 1909, or 15 days after inoculation, guinea pig died. No lesions were found aside from local necrosis at point of inoculation.

Smears made from the feces of Mabel showed no acid-fast bacteria.

Beginning Oct. 14, 1909, Expt. pig 285, a thrifty 50 lb. pig, was fed about four quarts of milk daily freshly drawn from Mabel. No particular precautions of cleanliness were taken in securing the milk.

Dec. 14, 1909, or after 61 days, Expt. pig 285 was carefully examined at post-mortem and no evidences of tuberculosis could be found. The pig had made great gains in weight.

From Dec. 14, 1909 until about March 14, 1910, a calf was allowed to

suck the Short Horn cow, Mabel. The calf was then slaughtered but showed no lesions of tuberculosis.

On March 4-5, 1910, the two cows used in these experiments were again tuberculin tested. They were in good condition. The reactions were as follows:

Before injection.

	8 a. m.	10 a. m.	12 m.	2 p. m.	6 p. m.	10 p. m.	12 m.
Rosa Flint	102.4	101.2	101.3	101.6	102.	101.3	100.9
Mabel	101.4	101.4	101.8	102	101.8	101.3	101.

After injection.

	6 a. m.	8 a. m.	10 a. m.	12 m.	2 p. m.	4 p. m.	5 p. m.	6 p. m.
Rosa Flint	101.	101.6	101.4	101.7	104.7	103.3	102.5	102.6
Mabel	101.5	101.4	102.	102.9	104.7	105.1	104.2	104.8

Rosa Flint gave no constitutional reaction.

Mabel showed slight constitutional symptoms such as chill, dry muffle, inappetense.

Both cows were slaughtered within a week of the test and a careful post-mortem examination made:

Rosa Flint showed only a few slight, calcified and encapsulated lesions in the bronchial lymph glands and lungs.

In Mabel, the right bronchial glands were greatly enlarged and the tubercular mass showed calcarious degeneration. The right cephalic lobe of the lungs contained a large tubercular mass undergoing liquefaction.

REFERENCES.

1. Schroeder and Cotton. The danger from tubercle bacilli in the environment of tuberculous cattle. B. A. I. Bul. 99.

2. Schroeder. Milk and its products as carriers of tuberculosis infection. B. A. I. Cir. 143.

3. Mohler and Washburn. Tuberculosis of Hogs. B. A. I. Cir. 144.

STUDIES IN PICKLE FERMENTATION.

Considerable effort was given to the off-fermentation of pickles during the fall of 1909 by Dr. Rahn and Miss Farrand. This work is a continuance of the investigations reported on last year.

There is not much to add, other than that the investigators feel greatly encouraged by their findings of the past winter. Beginning with August, the opening of the "pickling season," the studies will be again resumed.

LEGUME CULTURES.

During the past year, we have continued to send out nodule-forming bacterial cultures. It would be interesting to give the results from the use of these cultures, but owing to the many factors involved, we have felt it unwise; perhaps they would be greatly misleading.

We do feel that the results from the alfalfa cultures have been as highly satisfactory as could be expected, and further, feel that we can recommend the inoculation of alfalfa seed without stint. In case of the other legumes, many claim that they have secured benefit, while others have not. Only time will enable us to demonstrate the efficiency of cultures other than alfalfa. Much could be gained if a thorough test of these cultures could be made in the field.

The following cultures have been sent out during the past fiscal year: Number of cultures sent out from June 25, '09 to July 1st, 10.

No. cultures alfalfa, sent out	718
No. cultures red clover, sent out	155
No. cultures alsike clover, sent out	20
No. cultures white clover, sent out	3
No. cultures soy beans, sent out	12
No. cultures white beans, sent out	102
No. cultures peas, sent out	33
No. cultures cowpeas, sent out	49
No. cultures vetch, sent out	13
No. cultures sweet peas, sent out	2
Total	1,107
No. cultures for which collections are outstanding	14
No. cultures sent for special tests (gratis)	33

I append a revised letter of directions, suggestions and reports covering the inoculation of seed:

MICHIGAN AGRICULTURAL COLLEGE
BACTERIOLOGICAL LABORATORY.

Directions for using Nodule-Forming cultures for Legumes.

This culture is sent to you with the understanding that you will use it according to directions and report to us your success or failure. The price of the culture is 25 cents.

1. Cover the seed with water and let it soak for an hour. [For some seeds, this may be too long. See *Observations.*]
2. Mix a pound of granulated sugar with each bushel of wet seed. (This step is advised but it can be omitted.)
3. Spread the seed in a clean, shady place until dry enough to plant.
4. Pour a little cool water into the bottle of culture, break up the culture with a clean stick and mix it with the seed.
5. If the seed is still too wet and sticky to plant, it may be spread out again *in the shade.* It should be neither wet nor dry, but as moist as it can be and yet seed evenly. Plant the seed just as you would untreated seed.

6. Do not open the bottle until you are ready to treat the seed, and treat only as much seed as you can sow in a day.
7. A small strip should be planted with uninoculated seed for comparison *and this should be seeded first.*
8. Put a sample of uninoculated seed in one of the small envelopes and a sample of inoculated seed in the other and return to us in an addressed envelope.

OBSERVATIONS.

1. It is possible for the soaking to cause the seeds to swell too much, and thus perhaps injure them, especially if in drying too much time is consumed. *Beans are the most sensitive seed, consequently the time may be profitably cut down, if necessary, to a thorough wetting only.*

2. The drying should be accomplished rapidly and in the shade. The sun, if permitted to shine upon the seed, will destroy the micro-organisms very quickly.

3. Use only fresh cultures. Old cultures are probably worthless.

4. The micro-organisms grow upon the surface of the solid material (food material) in the culture bottles. They are the material wanted in the water suspension and not the solid material. The solid material should be stirred up as directed but, *because it does not dissolve, do not be concerned.* Hold the culture up to the light and observe the microbial growth on the surface of the solid material before the contents of the bottle are stirred.

5. If it is difficult to overcome the sticky condition of the seed, it will not be objectionable to mix pulverized soil in small quantities with the seed.

6. Sow the seed after inoculation as soon as possible. The life of the micro-organisms is involved on standing. *Soil should be moist.*

7. Do not estimate your crop solely by appearances; look for *nodules on roots* too. (See illustration in Cir. 5.) To do this, dig up roots very carefully, and do not pull them up.

8. Remember that the micro-organisms cannot overcome climatic conditions, quality of seed, cultivation of soil and crops, conditions of soil, and other influences. These micro-organisms represent *only one factor in successful leguminous crop production.*

9. This laboratory is not in position to say whether the culture will benefit your crop or not. Probably, if you have present in your soil a sufficient number of this class of micro-organisms, the culture is not needed. Only time and experience will demonstrate the boundaries of the usefulness of these cultures.

10. Beware of mistakes, carelessness, and ignorance of the steps you make.

11. The laboratory is frequently asked whether micro-organisms from one species of legumes may be used for another. This cannot be answered positively or satisfactorily. It appears to be possible, at times quite possible but in our experience, the micro-organisms peculiar to a species are best adapted to this species, and this alone.

Use this side for the purpose of answering questions only.

KEEP THIS UNTIL YOU CAN REPORT ON CROP

REPORT ON SEED INOCULATION.

[Answer concisely.]

Name .....
Address .....
Kind of seed..... When planted.....
Pounds of seed planted without culture.....
Pounds of seed planted with culture.....
Nodules on untreated seedlings.....
Nodules on treated seedlings.....
Vigor of growth with untreated.....
.....
Vigor of growth with treated.....
.....
Character of soil .....
Previous crops .....
Was your crop benefited by the treatment?.....
Do you want to try it again next year?.....
Further observations .....
Did you find the treatment easy of application?.....

Address,
Bacteriological Laboratory,
East Lansing, Mich.

Date of report.....

Write remarks on other side.

Remarks

LACTIC CULTURES.

This laboratory is ready to send out lactic cultures to all who may request them. A nominal charge of twenty-five cents is made to cover postage, container, and material. *It is the purpose of the laboratory to extend the use of lactic cultures and also make them the means of educating dairymen in their use.*

Circular No. 7 contains the essential features of a "starter," and attempts to describe their value as well as employment. Further than this, we are relying on Bulletin No. 746 to furnish the directions for using. This bulletin will be forwarded with each starter.

The following report is requested from all who use the starter:

MICHIGAN AGRICULTURAL COLLEGE
BACTERIOLOGICAL LABORATORY.

REPORT ON LACTIC CULTURE.

Name .....
Postoffice ..... County .....
State.....
Date of Churning..... Date of Report.....

USE IN BUTTER MAKING.

1. What was the character of your cream,—
   Condition.....Fat test in per cent.....
2. Was it sweet or sour?.....
3. Was it pasteurized or unpasteurized?.....
4. How old was it when the culture was added?.....
5. What per cent. of culture was added?.....
6. What was the temperature of ripening?.....
7. How long was it allowed to ripen?.....
8. What was the acidity when ripened?.....
9. How much color was added per 100 lbs. butter fat?.....
10. At what temperature was it churned?.....
11. What was the temperature of churning at the finish as shown by the butter milk? .....
12. What was the time required for churning?.....
13. What was the character of the butter when the fat first separated?
.....
14. How many times was the butter washed?.....
15. How many revolutions for each washing?.....
16. What was the temperature of the wash water?.....
17. What was the quality of the butter?.....
18. How much salt per pound of butter fat was used?.....
19. What was the per cent of over-run?.....

Please place a lump of butter as soon as worked in the parchment paper sent with starter, enclose it in mailing case of culture, and forward at once by mail to this laboratory. Send a lump as large as a walnut, at least.

QUESTIONS YOU MAY WISH TO ASK.

1.

2.

3.

4.

5.

CRITICISMS OF BUTTER, ET CETERA, BY COLLEGE DAIRY.

USE IN CHEESE MAKING.

1. Was the milk good flavored?.....
2. What was the acidity of the milk before culture was added?.....
3. How much culture was added to 100 lbs. of the milk?.....
4. What was the acidity when set?.....
5. What was the rennet test when set?.....
6. What was the length of time curdling?.....
7. How much rennet to 1000 lbs. milk was used?.....
8. What was the cooking temperature?.....
9. What was the time from setting to dipping?.....

10. What was the per cent of fat in the whey?.....
11. What was the per cent of acid in the whey?.....
12. What was the hot iron test at dipping?.....
13. Was the curd milled?.....
14. How long time from dipping to salting?.....
15. What was the hot iron test at salting?.....
16. How much salt to 1000 lbs. milk was used?.....
17. What was the time from salting to pressing?.....
18. How long was it pressed?.....
19. What was the yield of cheese for 100 lbs. milk?.....

QUESTIONS YOU MAY WISH TO ASK.

1.

2.

3.

4.

5.

CRITICISM OF METHODS, CHEESE, ET CETERA, BY COLLEGE DAIRY.

USE IN OTHER DAIRY PRODUCTS.

(Buttermilk, sour milk, milk beverages, cottage cheese, etc.)

PLEASE REPORT ON USE AND RESULTS.

Address,

BACTERIOLOGICAL LABORATORY,

East Lansing, Mich.

The application blank sent out with the circular provides a form for all those desiring to try out the "starter."

APPLICATION FOR LACTIC CULTURE.

Name .....

Postoffice ..... County .....

State.....

I desire to learn the nature of a lactic-culture starter, its use, and how it may be maintained; accordingly, I agree to follow the directions sent with the culture to the best of my knowledge and report the results in accordance with the questions submitted for this purpose.

Probable time of using culture.....

A nominal charge of 25 cents per culture is made to cover cost of

material and shipping. No amount less than a single culture will be sent. Two or more cultures will be forwarded at 25 cents *each*.

Enclosed find.....cents. *No stamps accepted.*

This sheet when filled out should be addressed to the

Bacteriological Laboratory,

East Lansing, Michigan.

Michigan Agricultural College.

VINEGAR CULTURES.

There is so much poor vinegar and so much cider wasted through off-fermentations, that it has been thought desirable to offer to farmers a culture and method for making vinegar. We feel that if, the suggestion given in Circular 9 of this report and the directions furnished with the culture are followed, there will be no trouble in making vinegar of first-class quality.

We refer the reader to Circular 9 and to the directions and blank report appended:

MICHIGAN AGRICULTURAL COLLEGE

BACTERIOLOGICAL LABORATORY.

Directions for using Alcohol-Acetic Cultures for Making Vinegar.

1. For each barrel of juice, prepare a two-quart Mason jar by washing thoroughly and inserting into boiling water.

2. Cover the top with a single layer of clean muslin or cheesecloth just removed from boiling water.

3. Tie the cloth over the top with a string about the neck of the can.

4. Take 7 or 8 medium sized *ripe apples,* pare and quarter or slice them. Place the prepared apples in one quart of water and boil till soft. Strain through clean cloth into the Mason jar after carefully removing the cloth from top. After the straining is completed, add 4 tablespoonsful of sugar, and place the cloth back on the top of the Mason jar and let the contents cool.

5. After the contents are cooled again partly remove the cloth cover from the jar.

6. Before opening the culture bottle place the *lips and cork (only)* ten seconds in boiling water.

7. Pour the contents of the culture bottle into the Mason jar and replace the cloth covering.

8. Keep the jar at a temperature of 75° F. to 90° F.

9. At first a foaming will be noticed, so familiar in the making of hard cider. This is the alcoholic fermentation and will appear in 2-4 days.

10. Following this is the acetic fermentation or the souring. A whitish film will appear on the surface of the liquid in 1-2 weeks, growing thicker and thicker with time. This is the "Mother-of-Vinegar."

11. As soon as a well defined film has formed, about 1-2 weeks after preparing, cut it up with scissors which have been dipped in boiling

water. Pour the entire contents of jar into the barrel of juice—as cider, grape juice, etc., which has just been expressed. *The barrel must not be more than two-thirds full and the bung-hole should be kept open.*

12. Keep the barrel at 65°-85° F. till vinegar has formed.

13. Place a little of the vinegar in the bottle sent you with the culture, filling the bottle one-fourth full, add a pinch of the mother-of-vinegar to it, insert in mailing case, and send it to this laboratory for examination.

14. When the fermentation is complete, after several weeks, bung the barrel and place it in a cool cellar.

REPORT ON ALCOHOL-ACETIC CULTURES.

Name .....

Postoffice ..... County .....

State.....

Date of Innoculating with Culture.....Date of Report.....

1. Did you follow directions as given.....
2. How soon did the foaming appear in Mason jar.....
3. How soon did the film appear in Mason jar.....
4. About what temperature was maintained for the fermentation in the Mason jar.....
5. To how much juice did you add the contents of the Mason jar.....
6. How much time elapsed between the pressing of the juice and the inoculating of it.....
7. What was the source of the juice.....
8. Was the fruit ripe or green.....
9. How soon did you notice any fermentation.....
10. What was its nature.....
11. How long did it continue.....
12. What was the taste.....
13. How soon did the acetic or souring fermentation appear.....
.....
14. How long did it continue before sending sample.....
15. What was the appearance of this fermentation.....
16. Is the vinegar clear.....
17. Is the vinegar pleasant to taste.....
18. Is the vinegar sufficiently acid.....

Other comments.

Address
Bacteriological Laboratory,
East Lansing, Michigan.

APPLICATION FOR ALCOHOL-ACETIC CULTURE.

Name .....

Post-office ..... County.....

State.....

I desire to coöperate with the Bacteriological Laboratory of the Michigan Agricultural College in its attempt to produce a better vinegar and to overcome losses by off-fermentations.

Probable time of using culture.....

If the culture is forwarded, I will

1. Carry out instructions received.
2. Observe all changes accurately.
3. Report on results as soon as the fermentation is completed by answering the questions asked in the "Report Blank" sent with the culture.

A nominal charge of 25 cents per culture is made to cover cost of material and shipping. No amount less than a single culture will be sent. Two or more cultures will be forwarded at 25 cents *each.*

Enclosed find.....cents. *No stamps accepted.*

This sheet when filled out should be addressed to the

Bacteriological Laboratory,
East Lansing, Michigan.

Michigan Agricultural College.

HOG CHOLERA SERUM.

Last year, we made quite a complete report of our work. Since we feel the results highly satisfactory, there is added only a tabulated report of herds treated and also a statement of cost of production:

Herd.	Date of treatment.	No. of animals treated.	No. of animals alive.	No. of animals dead.	Condition of herd when treated.
50	12/ 1/08	13	8	5	Incomplete.
51	5/10/08	13	8	5	Part of herd sick with disease.
52	11/19/08	10	10	0	Disease on place. Herd O. K.
53	11/17/08	19	18	1	Disease on place two weeks. Two pigs had died.
54	11/17/08	7	4	3	Disease on place two weeks. Herd in poor condition.
55	.....	.....	.....	.....	Cancelled.
56	1/29/09	62	58	4	Disease existed in herd for 20 to 25 days.
60	1/22/09	11	11	0	Good.
61	2/18/09	7	7	0	Good.
62	2/24/09	2	2	0	Disease on place last fall.
63	3/26/09	158	114	44	Disease existed in herd.
64	3/19/09	1	1	0	Good.
65	3/19/09	3	3	0	Good.
66	7/19/10	12	0	12	Disease on place. Badly infected.
68	4/27/09	15	8	7	Disease on place.

Herd.	Date of treatment.	No. of animals treated.	No. of animals alive.	No. of animals dead.	Condition of herd when treated.
69	4/27/09	.....	.....	.....	Incomplete.
71	6/25/09	24	24	0	
72	6/ 3/09	24	24	0	Disease just begun.
74	6/12/09	21	21	0	Had on place last fall.
75	7/22/09	4	4	0	Healthy.
76	7/12/09	23	23	0	Seemed to be in fair condition.
80	9/ 1/09	37	37	0	Disease appears periodically.
81	8/31/09	123	123	0	Disease appears periodically.
82	9/23/09	17	17	0	Disease appears periodically.
83	9/ 8/09	1	1	0	Disease appears periodically.
84	9/ 9/09	55	16	39	Badly infected. Disease in herd three weeks.
85	9/ 9/09	38	.....	.....	Incomplete.
86	10 /6/09	52	50	2	
87	10/20/09	75	73	2	Disease on place.
88	10/23/09	38	.....	.....	Incomplete.
89	10/ 6/09	52	25	27	Disease on place. Badly infected.
90	.....	.....	.....	.....	Cancelled.
91	10/ 6/09	75	68	7	Disease on place.
93	10/21/09	148	147	1	10 to 12 sick hogs on place.
94	10/30/09	14	12	2	Fair. Disease existed on place.
95	11/25/09	225	225	0	O. K.
96	11/ 1/09	173	130	40	Herd exposed to disease.
100	11/11/09	70	65	5	Several animals sick.
102	2/19/09	33	28	5	Disease began 6/3/09.
104	2/19/10	15	15	0	Not given. (No ill effect after use of serum).
105	.....	.....	.....	.....	Cancelled.
110	2/16/10	28	26	2	One-half of herd affected.
118	.....	.....	.....	.....	Cancelled.
124	.....	.....	.....	.....	Cancelled.
128	1/13/10	14	13	1	One-half of herd dead.
131	1/25/10	53	.....	.....	Incomplete.
139	5/30/10	7	6	1	75 per cent sick or dead.
140	5/21/10				
141	.....				
143	.....				
144	.....	132	111	21	Disease appears on place periodically. On place since 4/1/10. At the time of beginning treatment, there were several animals sick. One had died.
145	.....				
146	.....				
147	6/15/10				

Financial Report on Hog Cholera Serum Manufacture. July 1st, 1909 —July 1st, 1910.

Feed—concentrated	$641 84
Straw and roughage	82 70
Swine	1,043 42
Apparatus	100 00
Travel	26 87
Labor other than expert supervision	1,400 00
	$3,294 83

VALUE OF RECEIPTS AND PRODUCTS ON HAND.

Actual receipts for serum	$3,320 00
Actual receipts for pigs	394 12
Value of tested serum on hand	866 96
Value of untested serum on hand	200 00
Value of unmixed and untested serum	350 00
Value of hogs on hand	568 10
Value of prospective serum in hogs	505 82
	$6,205 00
Deducting products on hand July 1st, 1909	2,882 58
Actual value of products for year	$3,322 42

Serum—

Total No. cc. on hand—good, July 1st, 1909	93,084 cc.
Total No. cc. on hand—untested, July 1st, 1909	57,813 cc.
Total No. cc. on hand—poor, July 1st, 1909	28,618 cc.
Total No. drawn and mixed, July 1, '09—July 1, '10	99,117 cc.
Total No. drawn not mixed, July 1, '09—July 1, '10	21,351 cc.
Total No. drawn for experiment	2,810 cc.
Total	302,793 cc.
Total No. cc. sold, July 1st, '09—July 1st, '10	164,855 cc.
Total No. cc. used for testing serum	2,412 cc.
Total No. cc. mixed serum on hand tested	43,348 cc.
Total No. cc. mixed serum on hand not tested	13,536 cc.
Total No. cc. not mixed on hand	21,351 cc.
Total No. cc. poor serum from last year destroyed	27,190 cc.
Total No. cc. drawn for experiment	2,810 cc.
Total No. cc. poor serum on hand	23,910 cc.
Total No. cc. breakage and error	3,381 cc.
Total	302,793 cc.
No. cc. for which collections are outstanding	1,715 cc.

Some results have been collected by Dr. Giltner from his studies of the cellular elements of the blood of hyperimmune hogs subjected to bleeding at various periods for serum. This will be of particular interest to those engaged in the preparation of serum:

THE EFFECT ON CELLULAR ELEMENTS OF THE BLOOD OF REPEATED BLEEDINGS DURING HOG CHOLERA SERUM PRODUCTION.

So far as we know, no effort has been made by other workers in the field of hog cholera-serum production to determine the effect on the numbers of blood cells of the weekly tail bleedings of serum hogs.

Burnett[1] has made an exhausive study of the literature on the blood of animals. From his work, the following citations are made:

"Moore, Haring and Cady[2] found an increase in three horses of 2,965,000, 3,084,000 and 2,803,000 red corpuscles after complete chloroform anaesthesia of from one and one-half to two hours. In the first two cases, operations with considerable hemorrhage were performed; in the last case, the only operation was puncture of the gutteral pouch, a trifling one, with no hemorrhage." It is difficult to say how much of this polycythemia should be attributed to the anaesthetic and how much to hemorrhage. It is known, however, that a temporary increase in the number of erythrocytes per ccm. immediately succeeds hemorrhage soon followed by a decrease as the volume of blood is replaced by absorbed liquid. The rate at which this decrease is continued and later replaced by an increase to normal is well illustrated by the following table from Smith.[3] The table was prepared in connection with a study of the effect of the piroplasma of Texas fever on the blood and shows the effects of repeated bleedings on the number of red corpuscles in the cow.

Date.	No. of red corpuscles.	Quantity of blood withdrawn.	Remarks.
Aug. 3	6,750,000	2,268 kgr.	Blood elements not visibly changed.
Aug. 4	5,000,000	2,325 kgr.	Blood elements not visibly changed.
Aug. 5	4,650,000	.....	Blood elements not visibly changed.
Aug. 6	5,220,000	3,828 kgr.	Blood elements not visibly changed.
Aug. 7	3,820,000	4,251 kgr.	Blood elements not visibly changed.
Aug. 8	3,090,000	4,989 kgr.	2-3 per cent show stained granules; about 10 per cent appear enlarged.
Aug. 10	2,250,000	.....	20 per cent macrocytes, 15 per cent contain stainable material, chiefly as granules.
Aug. 11	2,140,000	.....	Same as yesterday.
Aug. 12	2,110,000	.....	Same as yesterday; one erythroblast.
Aug. 14	2,530,000	.....	Numerous macrocytes; about 5 per cent contain stained particles.
Aug. 17	3,200,000	.....	Macrocytes as before; cells with granules rare.
Aug. 22	3,200,000	.....	Macrocytes as before; no stained granules detected.
Aug. 29	4,300,000	.....	Only a few macrocytes.

The following points on the restoration of blood after hemorrhage are of interest in this connection (Burnett 1. c., p. 61).

"In small animals the restoration of the *volume* of *blood* is rapid while in the larger animals it may be 35-40 minutes (V. Limbeck) before the increased volume is noticeable. With small animals the restoration of the red corpuscles is more rapid, three to four weeks, while in the larger animals a longer time is required, 19-34 days (Lyon). The rapidity of the loss of blood has a marked effect on the rate of restoration to

the normal, recovery being slower after rapid than after slow bleeding. Several hemorrhages, though smaller in amount than from a single one greatly delay restoration, and produce a more severe form of anemia. The rapidity of restoration depends on the state of nutrition of the animal. It has been found that recovery is hastened by a full diet, and abundant supply of water and is more rapid with tranfusion of salt solution."

The changes in the individual elements vary greatly, depending upon the severity of the anemia. Alterations in size, especially the appearance of macrocytes are common, unusual staining reactions such as diffuse basophile (methylene blue, with Wright's stain) staining, (polychromasia) or separate bluish points (punctate basophilia) may appear. Deformed red cells (poikilocytosis) and nucleated red cells (erythroblasts) may also be found.

From the economic standpoint, it is only the production of immune bodies in the blood serum that is desired. As already observed, the increase in volume of blood is rapid while the number of red cells could not be replaced from one severe weekly bleeding to the next. We do not know what is the effect of this oligocythemia on the ability of the body cells to produce antibodies. It would seem that in this connection the only effect would be in a general way by the lessened oxygen-carrying power of the blood, and consequent lessened vitality of the animal, unless the red cells are especially concerned in antibody production.

In the following blood examinations, we may use for a basis of comparison the results obtained by myself on normal pigs examined at another time.[4]

Erythrocytes: 7,924,000.
Leucocytes: 19,000.

	Extremes.	Averages.
Lymphocytes	30–79.8	51.6
Large mononuclears	8–10.	4.6
Polynuclears	13–60	37.
Eosinphiles	1.2–11	5.2
Mast cells	2–5.6	1.3

Serum Hog No. 1. Chester White pig, wt. ca. 100 pounds; hyperimmunized by slow method. Bled from tail weekly for seven times since last injection of virus.

Blood examination before eighth bleeding.
Erythrocytes: 5,816,000.
Leucocytes; 14,000.

	Percentage.	Number.
Lymphocytes	38	5,320
Large mononuclears	1	140
Polynuclears	57.2	8,008
Eosinphiles	1.8	252
Mast cells	2	280

Blood platelets in clusters, very numerous.

Blood examination after eighth bleeding of ca. 800 cc. blood (20 minutes later).

Erythrocytes: 6,016,000.

Leucocytes: 12,600.

	Percentage.	Number.
Lymphocytes	28.4	3,578.4
Large mononuclears	4.4	554.4
Polynuclears	61	7,686
Eosinphiles	4.6	579.6
Mast cells	1.6	201.6

Blood platelets in clusters, very numerous.

Many erythrocytes show polychromasia.

Serum Hog No. 10. Weight, 75 pounds+; hyperimmunized by slow method. Bled three times since last injection of virus.

Blood examination before fourth bleeding.

Erythrocytes: 6,704,000.

Leucocytes: 12,800.

	Percentage.	Number.
Lymphocytes	53	6,784
Large mononuclears	3	384
Polynuclears	38.8	4,966.4
Eosinphiles	3.4	435.2
Mast cells	1.8	239.4

Blood platelets more numerous than after bleeding.

Blood examination after fourth bleeding of ca. 600 cc. blood (40 min. later).

Erythrocytes: 6,968,000.

Leucocytes: 13,200.

	Percentage.	Numerous.
Lymphocytes	36.6	4,831.2
Large mononuclears	.6	79.2
Polynuclears	60.	7,920
Eosinphiles	2.6	343.2
Mast cells	.2	26.4

This pig always suffered from dyspnoea when blood was being drawn, although he was comparatively quiet. At autopsy, one week after this blood examination, cephalic lobes of lungs were found hepatized; ventral lobes congested.

Serum Hog No. 20. Weight, ca., 90 pounds; hyperimmunized by slow method. Bled once since last injection of virus.

Blood examination before second tail bleeding.

Erythrocytes: 7,516,000.

Leucocytes: 23,200.

	Percentage.	Number.
Lymphocytes	62.4	14,476.8
Large mononuclears	1.2	278.4
Polynuclears	33.6	7,795.2
Eosinphiles	2.2	510.4
Mast cells	.6	139.2

Blood plates more numerous than after bleeding.

Polychromasia pronounced.

Blood examination after second bleeding of ca. 800 cc. (30 min. later).

Erythrocytes: 7,432,000.

Leucocytes: 28,000.

	Percentage.	Numerous.
Lymphocytes	61.8	17,304
Large mononuclears	3.6	1,008
Polynuclears	32	8,960
Eosinphiles	2.2	616
Mast cells	.4	112

Polychromasia.

Serum Hog No. 42. Weight, ca. 110 pound; hyperimmunized by slow method. Bled weekly for four times since last injection of virus.

Blood examination after fourth bleeding of about 900 cc.

Erythrocytes: 7,390,000.

Leucocytes: 14,000.

	Percentage.	Number.
Lymphocytes	42	5,880
Large mononuclears	1	140
Polynuclears	44	6,160
Eosinphiles	11.5	1,610
Mast cells	1.5	210

Less than 1,000,000 blood plates (less than usual before bleeding).

Serum Hog No. 54. Weight, ca., 100 pounds; hyperimmunized by slow method. Bled once since last injection of virus.

Blood examination before second bleeding.

Erythrocytes: 5,712,000.

Leucocytes: 20,000.

	Percentage.	Number.
Lymphocytes	43.8	8,760
Large mononuclears	1.6	320
Polynuclears	50	10,000
Eosinphiles	3.2	640
Mast cells	1.4	280

Many erythrocytes show polychromasia and many fail to stain with eosin at all. At autopsy, three weeks later, pig showed diffuse chronic pleuritis with adhesion of both lungs to paretal pleura; diffuse chronic peritonitis with adhesions and fibrinous shreds on liver and spleen. Pig had shown great difficulty in breathing since hyperimmunization.

Serum Hog No. 1. Comparison before and after eighth bleeding.
Erythrocytes increased 200,000 after bleeding.
Leucocytes decreased 1,400 after bleeding.

	Decrease or increase.	Actual numbers.	Decrease or increase.	Percentage.
Lymphocytes	Decreased..	1,741.2	Decreased..	9.6
Large mononuclears	Increased...	414.4	Increased...	3.4
Polynuclears	Decreased..	322	Increased...	3.8
Eosinphiles	Increased...	327.6	Increased...	2.8
Mast cells	Decreased..	78.4	Decreased..	.4

Serum Hog No. 10. Comparison before and after fourth bleeding.
Erythrocytes increased 264,000 after bleeding.
Leucocytes increased 400 after bleeding.

	Decrease or increase.	Actual numbers.	Decrease or increase.	Percentage.
Lymphocytes	Decreased..	1,952.8	Decreased..	16.4
Large mononuclears	Decreased..	304.8	Decreased..	2.4
Polynuclears	Increased...	2,953.6	Increased...	21.2
Eosinphiles	Decreased..	92	Decreased..	.8
Mast cells	Decreased..	204	Decreased..	1.6

Serum Hog No. 20. Comparison before and after second bleeding.
Erythrocytes decreased 84,000 after bleeding.
Leucocytes increased 4,800 after bleeding.

	Decrease or increase.	Actual numbers.	Decrease or increase.	Percentage.
Lymphocytes	Increased...	2,827.2	Decreased..	.6
Large mononuclears	Increased...	729.6	Increased...	2.4
Polynuclears	Increased...	1,164.8	Decreased..	1.6
Eosinphiles	Increased...	105.6	No charge..	.....
Mast cells	Decreased..	27.2	Decreased..	.2

GENERAL OBSERVATIONS.

1. The successive weekly bleedings of serum hogs lessen the number of erythrocytes in proportion as the number of bleedings increases.

2. In most cases, the number of leucocytes is decreased.

3. The decrease in number of leucocytes is due to a constant decrease in large mononuclears, and a nearly constant decrease in lymphocytes and eosinophiles while this disease is only partially offset by a nearly constant increase in polynuclears and mast cells.

4. There may be a slight temporary increase in the number of erythrocytes per cmm. immediately after bleeding.

5. There is a tendency for both the actual numbers and the percentages of lymphocytes to decrease and of polynuclears to increase immediately after bleeding.

6. Changes in the staining properties of the erythrocytes may result from repeated bleedings of serum hogs.

7. The changes noted in this connection are in harmony with what has been observed by others in studying the effects of hemorrhage on the cellular elements of the blood.

COMPARISON WITH THE AVERAGE NORMALS.

	Serum hog No. 1 before eighth bleeding.	Serum hog No. 1 after eighth bleeding.	Serum hog No. 10 before fourth bleeding.	Serum hog No. 10 after fourth bleeding.	Serum hog No. 20 before second bleeding.	Serum hog No. 20 after second bleeding.	Serum hog No. 42 after fourth bleeding.	Serum hog No. 54 before second bleeding
Erythrocytes—fewer	2,108,000	1,908,000	1,222,000	956,000	408,000	492,000	534,000	2,212,000
Leucocytes—fewer	5,000	6,400	6,200	5,800	4,200a	9,000a	5,000	1,000a
Lymphocytes.—fewer	13.6%	23.2%	1.4%	15 %	10.8%a	10.2%a	9.6%	7.8%
Large mononuclears—fewer	3.6%	.2%	1.6%	4 %	3.4%	1 %	3.6%	3 %
Polynuclears—more	20.2%	24. %	1.8%	23 %	3.4%b	5 %b	7 %	13 %
Eosinphiles—fewer	3.4%	.6%	1.8%	2.6%	3 %	3 %	6.3%a	2 %
Mast cells—more	.7%	.3%	.5%	1.1%b	7%b	9%b	.2%	.1%

a. more.
b. fewer.

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DEVELOPMENT OF MICRO-ORGANISMS IN SERUM.

Because of the trouble arising from the use of one-half per cent carbolic acid in the preservation of serum, it may be of interest to review the results of numerous determinations of the bacterial content of various lots studied for this particular purpose. This work was carried out by Mr. J. L. Whitney of this laboratory.

Serum—number of lot.	Temperature maintained for plates.	Age of plate.	Bacteria per cc.		
			1–10	1–100	1–1,000
No. 21	21°C.	2 da	4,900 x	5,200 x	5,000 x
No. 31	37½°C.	2 da	3,420 x	1,900 x	Contaminated.
			1,950 x	2,000 x	1,000 x
No. 31	5°C.	7 da	170 z	2,600 z	1,000 z
No. 25	21°C.	2 da		204,500 x	480,000 x
No. 25	37½.C.	2 da		189,000 x	52,000 x
No. 25	5°C.	7 da		220,000 x	165,000 x
No. 30	21°C.	2 da		1,494,000 x	2,435,000 x
				729,000 x	825,000 x
No. 30	37½°C.	2 da		126,000 z	94,000 z
No. 30	5°C.	7 da		1,467,000 x	1,735,000 x
No. 36	21°	2 da		1,608,500 x	180,000 x
No. 36	5°C.	7 da		1,635,300 x	5,000
No. 23	21°C.	2 da		394,000	500,000
				7,500 x	7,000 x
No. 23	5°C.	7 da		3,400 z	1,000 xz
					17,000 x
No. 21	21°C.	3 da		66,800	30,000 xz
No. 21	5°C.	7 da	22,000 x	39,700 x	15,000 x
			25,000 xz	2,200 z	3,000 z

A study of these bacteria microscopically showed no difference in size, motility or structure. The colonies (x and z) were much the same in appearance. No pathogenicity could be demonstrated on guinea pigs and rabbits.

CONTAGIOUS ABORTION.

Dr. Ward Giltner has been making some progress with this disease and has been able to hold it in check by the method recommended last year, whenever there has been an opportunity to follow up the treatment vigorously. Usually the treatment will eliminate the disease completely, but from time to time a persistent type of epidemic is met with, which does not yield readily to present methods.

What time has been available for this work, Dr. Giltner has been giving to a more intimate study of its nature, hoping thereby to secure results which will be of utility in its eradication. In connection with this work and incidental to it, Dr. Giltner offers the following results in connection with the use of lactic cultures for irrigation in contagious abortion and several distinct maladies.

ON THE THERAPEUTIC ACTION OF LACTIC ACID CULTURES.

Considerable attention is being paid to the use of lactic acid producing bacteria in the prevention of undesirable bacterial growths and even in combating the development of pathogenic and toxicogenic bacteria. Metchnikoff[1] has emphasized the value of lactic acid producing bacteria in the counteraction of intestinal fermentation and the resulting auto-intoxication and arterio sclerosis in man. There is an ever increasing literature on the beneficial effects of fermented milk beverages.

Dr. C. E. North,[2] working in the Lederle Laboratories, reports a series of interesting cases of varied types many of which were treated successfully by the substitution of lactic acid cultures for the usual antiseptics.

Some organism resembling B. bulgaricus has been used in most of this work, probably on account of its high acid production. An account is given in the Amer. Sugar indus. and Beet Sugar Gaz. 12 (1910), No. 2, p. 39, of the use of lactic acid cultures in sprinkling beet chips to prevent the growth of bacteria that would cause decomposition and render the material unfit for food. The results were favorable, both in the appearance of the silage produced and in its effect on steers fed.

Extended researches have been carried on in this laboratory under the direction of Dr. Marshall by Miss Northrup, with a view to determine the action of lactic acid cultures on typhoid bacteria. The results, not yet published, indicate a restraining action.

At the suggestion of Dr. Marshall, the following tests were conducted with the hope of finding a substitute for the ordinary coal tar and chemical antiseptics in the irrigation of the genital organs of cows after infectious abortion. Incidentally, the cultures have been used in surgical cases and in an attempt to overcome sterility in cows.

No. 1. Dairy grade, 24 B, aborted Aug. 24, '09. Due to calve Oct. 22, '09. The afterbirth was removed within 12 hours after the act of abortion. Many of the cotyledons showed the characteristic, dirty, yellowish-brown appearance of infectious abortion.

8-25-09, cow was discharging some; no appetite; abdomen tucked up. Gave tonic and appearance improved on following day.

8-27-09, flushed with about 8 qts. of 5% L. C. Comp.

9-14-09, still discharging so that tail and buttocks are constantly soiled. Flushed with 8 qts. 5% L. C. Comp.

9-18-09, examined per vaginam. Found os closed and vaginal mucosa covered with a clean, viscid mucus, but no pus or necrotic material. Irrigated vagina with 1.5l sterile .85% Nacl solution. Syphoned off salt solution and injected 250 cc. 40 hour (37° C.) lactic culture II in 2% lactose bouillon.

9-24-09, examined per vaginam and found os closed and considerable clear, thick, tenacious mucus streaked with blood.

Since last injection, only a perceptible amount of clear, viscid discharge had been noted.

Injected 1.5l .85% Nacl solution followed, after drainage with 250 cc. culture as before.

9-30-09, returned to herd free from discharge.

3-12-10, bred; failed to conceive.

4-28-10, bred.

Rosa Flint II aborted 10-6-09. Retained afterbirth.

10-9-09, tail and buttocks soiled with uterine discharge and part of afterbirth hanging from vulva. Removed afterbirth manually. Flushed with 1.5l sterile .85% Nacl solution. After draining, injected 250 cc. of 48 hour (37° C.) culture lactic germ II in 2% lactose bouillon.

10-11-09, only slight discharge soiling tail. Injected 250 cc. culture as before.

10-13-09, very slight purulent discharge at inferior commissure of vulva. Injected 250 cc. culture as above. No discharge after this date. Never any straining and appetite good.

3-30-10, sold to butcher. Generative organs appeared normal.

Nov. 1, 09, Rosa Fairview, Short Horn, isolated on account of symptoms of abortion, viz., udder swollen and oedematous and lips of vulva slightly swollen.

11-2-09 at 4 p. m., restless and straining considerably. At 9 p. m., a manual exploration of vagina showed the os uteri wide open and distended with the intact fetal membranes. The membranes were opened and the waters evacuated were dirty red in color. The dead foetus was removed with considerable difficulty. It was a male about 8 months old and well developed. The afterbirth was attached only at the fundus of the uterus and was removed immediately. The afterbirth showed numerous dirty yellow cotyledons, the other being excessively red, and the subchorial tissue was oedematous in places. The umbilical cord was detached from the foetus and was very soft and friable. A large quantity of dirty and blood-stained fluid with necrotic material in suspension was discharged by uterine contractions. The cow received no additional treatment.

11-12-09, no treatment had been administered up to this date, when a considerable dirty, purulent and necrotic discharge was noted.

11-15-09, still discharging. Flushed with 2l. sterile .85% Nacl solution, followed by 250 cc. lactic culture II in 2% lactose bouillon grown 2 days at 37° C. and 9 days at room temperature.

11-18-09, tail soiled with discharge. Injected 250 cc. of 48 hr. (37° C.) culture of lactic germ II in 2% lactose bouillon. Acidity, 60°.

11-20-09, tail very slightly soiled.

11-24-09, Ditto.

11-30-09, discharge consisted of slight amount of clear blood-stained mucus.

12-6-09, returned to herd clean.

3-1-09, bred. Not in heat since.

Bertha M., Brown Swiss, dropped calf 2 weeks before end of normal period, Nov. 4, '09. She had shown swollen udder and lips of vulva for nearly two weeks. Calf lived. Nearly all cotyledons were dirty yellow, few intensely red. Considerable dirty exudate. No treatment.

11-5-09, removed afterbirth manually, with no further treatment.

11-12-09, considerable discharge. Flushed with 2% L. C. Comp.

11-15-09, still discharging. Flushed as above.

11-18-09, discharging considerable thick creamy pus.

11-20-09, discharge continues.

11-22-09, flushed with 2l. sterile .85% Nacl solution. After draining, injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose bouillon.

11-24-09, discharging only enough to soil tail. Injected 250 cc. culture as above, 70° acid.

11-26-09, quite clean. Injected 250 cc. culture as before.

11-30-09, clean.

12-6-09, returned to herd.

2-7-10, bred. Not in heat since.

A Holstein heifer, College Colantha Queen 2nd's heifer, aborted at about 8 months, 12-9-09.

12-10-09, removed the afterbirth and flushed with 2l. sterile .85% Nacl solution, followed by 170 cc. 24 hr. (37° C.) culture lactic germ II in 2% lactose bouillon. Acidity, 60°.

12-13-09, nearly clean. Injected 250 cc. 72 hr. (37° C.) culture lactic germ II in 2% lactose bouillon. Acidity, 50°.

12-18-09, tail only slightly soiled. Injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose bouillon. Acidity 60°.

1-5-10, returned to herd clean.

3-5-10, bred.

3-26-10, bred again. Not in heat since.

On Dec. 8, 09, Sharon Duchess, a tuberculous Short Horn, aborted about one week before full term. The cow was in very thin flesh.

12-17-09, discharging considerable pus and necrotic material. Injected 2l. sterile .85% Nacl solution followed by 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose bouillon. Acidity, 60°.

12-22-09, tail slightly soiled.

Injected 250 cc. 48 hr. (37° C.) culture in 2% lactose diluted bouillon. Acidity, 48°.

1-5-10, tail showed considerable accumulation of uterine discharge. Injected 250 cc. 40 hr. (37° C.) culture lactic germ II in 2% lactose diluted bouillon. Acidity, 45°. Remained clean after this date.

2-4-10, killed. Uterus normal; os closed; vaginal mucosa slightly congested. Extensive tuberculous lesions in thoracic cavity.

Scrub cow calved normally Dec. 21, '09, but retained afterbirth.

12-22-09, removed afterbirth with some difficulty and considerable hemorrhage. Injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose bouillon. Acidity, 70°.

12-24-09, no discharge since last treatment. Injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose diluted bouillon. Acidity 45°.

No discharge after this date. Animal sold and no further history available.

College Bonnie, Guernsey heifer, aborted Dec. 26, '09.

12-27-09, removed afterbirth. Cotyledons generally dirty yellow. Maternal cotyledons greatly enlarged. No treatment.

12-29-09, showed slight discharge. Injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose diluted bouillon. Acidity, 40°.

1-5-10, clean. No discharge since use of culture.

3-5-10, killed on account of tuberculosis. Genital organs normal.

Dec. 31, '09, opened abscess in left gluteals of Angus calf and evacuated about one pint of thick, viscid, creamy pus. Washed out with 2% L. C. comp. Packed with cotton and powdered $CuSO_4$.

1-5-10, removed pack and found abscess lined with granulation tissue. Flushed with one quart of sterile .85% Nacl. solution and injected 250 cc. 40 hr. (37° C.) culture of lactic germ II in 2% lactose diluted bouillon. Acidity, 40°.

1-14-10, no discharge from this wound since treatment with culture. Wound nearly healed. Washed with lactic culture. Healing rapid and complete.

Jan. 8, '09, opened abscess on right cheek of Holstein calf 2 weeks old. Removed most of fibrous capsule through cutaneous incision and packed with cotton and powdered $CuSO_4$.

1-10-10, removed pack and washed with 2% L. C. Comp.

1-14-10, there was considerable inflammatory swelling about wound and necrotic tissue and purulent discharge abundant. Washed out with lactic culture VII, 54° acid, and packed with cotton soaked in same.

1-15-10, cleaned out abscess with same culture as used yesterday and packed with cotton soaked in same. Contained considerable necrotic tissue in a pulpy mass with healthy granulation tissue underneath.

1-16-10, not so much necrotic tissue and pus; red, healthy granulation tissue at bottom. Washed out with lactic culture II grown 2 days at 37° C. and 2 days at room temperature in 2% lactose diluted bouillon. Acidity, 40°.

1-17-10, doing nicely; less swelling and discharge. Used same culture as yesterday. Healed quickly.

Coloma Canary, Holstein cow, calved normally 1-3-10, but did not pass afterbirth readily and may have retained a portion of it.

1-14-10, from the 6th to this date, she passed considerable uterine discharge containing blood and necrotic tissue. Injected 250 cc. 40 hr. (37° C.) culture lactic germ II in 2% lactose bouillon. Acidity, 80°. (A culture made at same time in 2% lactose dilluted bouillon was only 40° acid. Discharge ceased quickly.

2-2-10, died suddenly of acute indigestion. At post-mortem, genital organs found normal.

Ray G III, a Short Horn heifer, calved normally but retained afterbirth.

1-24-10, removed afterbirth manually. No indication of infectious abortion.

1-26-10, injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose diluted bouillon. Acidity, 58°.

1-31-10, considerable necrotic, foul-smelling discharge for several days. Injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose diluted bouillon. Acidity, 60°. Discharge ceased quickly.

Grade Angus No. 6 aborted 2-9-10. Calf lived. Removed afterbirth. Nearly all cotyledons brownish yellow; considerable dirty brown exudate. Injected 200 cc. lactic culture II grown 24 hrs. at 37° C. and 24 hrs. at room temperature in 2% lactose diluted bouillon. Acidity, 60°.

2-14-10, only slight discharge. Injected 250 cc. 72 hr. (37° C.) culture lactic germ II in 2% lactose diluted bouillon. Acidity, 45°.

2-21-10, discharging considerable dirty brown exudate. Injected 250 cc. 48 hr. (37° C.) culture lactic germ II in 2% lactose diluted bouillon. Acidity, 60°.

3-5-10, discharge slight since last injection. Injected 250 cc. 3 day (37° C.) lactic culture (high acidity) in 2% lactose diluted bouillon. Acidity, 50°.

Discharge soon ceased.

Feb. 19, '10, opened tumor on cheek of Ayrshire-Brown Swiss calf. The swelling had existed for over a week and had erupted through oral

mucosa. Only a portion of the fibrous growth removed through a crucial incision in the skin. Packed with lactic culture II.

2-20-10, renewed pack.

2-21-10, removed pack. Healing complete in few days, characterized by absence of much discharge.

Treatment of Holstein cow, Queen Ykema Houwtje.

This cow aborted twice prior to Oct. 22, '08, when she showed symptoms of impending abortion. She was due to calve Dec. 17 '08. She was fed 140 cc. 5% phenol daily in ground feed and injected subcutem every other day with 30 cc. 2% phenol.

Abortion occurred Oct. 29, 08. Nearly all the cotyledons were dirty yellow in color, characteristic of infectious abortion.

The afterbirth was passed naturally and the cow flushed with ½% lysol several times. She never discharged much.

Repeated attemps to breed this cow during 1909 failed.

Jan. 18, '10, cow in oestrum. Injected 250 cc. lactic acid culture (prepared as usual). Feb. 2, '10, injected 250 cc. lactic culture 48 hr. old in diluted 2% lactose bouillon. Acidity, 60°.

Feb. 5, '10, injected 250 cc. lactic culture 24 hrs. old.

Feb. 9, '10, in oestrum. Bred.

Mar. 5, '10, not in oestrum.

Apr. 20, 10, in oestrum (?). Bred.

May 5, '10, cow killed because it was thought that she was not in calf.

An examination of the carcass showed the vulva quite thickly studded with vesicles described as occurring in "Infections Granular Vagnitis."[4] In the uterus was found a perfectly normal male foetus which must have had its inception at the service on Feb. 9, '10, judging from its size. Inoculation in 5% lactose bouillon from uterous remained sterile; from vagina showed a colon-like bacillus only.

The use of lactic acid cultures is being continued in similar cases.

1. Metchnikoff—Prolongation of Life. New York.

2. North. Reports of 300 cases treated with a culture of lactic acid. bacteria. Med. Record. March 27, 1909.

3. Trans. from Zeitschift für Spiritus Industrie; Abs. in Exp. Sta. Rec. XXII, No. 6, p. 573.

4. Wills, J. G. Some Remarks on Venereal Disease in Cattle. Am. Vet. Rev. XXXVI. No. 3.

I have also to add several other reports covering diseases which Dr. Giltner was called upon to investigate.

THE STOMACH WORM IN SHEEP IN KENT COUNTY.

Letters were received at the Bacteriological Laboratory from Dr. Fred W. Olley of Caledonia, Michigan, on the 20th, 21st, 26th of July, 1909, in regard to an outbreak of a disease in sheep.

A dead sheep was received by express, July 26th, from the farm of Mr. M———, a patron of Dr. Olley's, but delay in transit made a post mortem very unsatisfactory.

On July 27th, I visited the farm of Mr. M———, Gaines township,

Kent county, in company with Dr. Olley, and made an autopsy on a male lamb. The lamb had been killed in the morning by a blow on the head, and had been buried several feet under a sandy soil. The lamb was disinterred and examined at about sun-down of the same day.

Autopsy: Fairly good condition; visible mucous membranes, very pale and bloodless; a considerable oedematous swelling in the inter-maxillary space. Only a slight increase in pleuritic pericardial and peritoneal fluids. All the organs of the thoracic and abdominal cavities were very pale and contained less blood than normal, but were otherwise normal. The stomachs were partly distended with grass in process of digestion. The abomasum contained a seething mass of stomach worms (Haemonchus contortus) mixed with the ingesta and thickly covering the mucosa in places. Several specimens of the Caecum or Whip worm (Trichocephalus affinis) were found attached to the mucous membrane of the Caecum.

Mr. M——— had bought a number of sheep of a stock buyer the previous fall. He had lived on the farm a long time, succeeding his father, and they had never lost any number of sheep before. None of the farmers in the immediate vicinity had lost any sheep. Mr. M——— had lost about 50% of a flock of lambs numbering nearly 60, in addition to several ewes. The sheep were found on a good clover meadow, and were given plenty of pure water from a driven well. The pasture was part clay and part sandy and contained no wet places. The sheep were in fair condition, but many of them were weak, as was evidenced by general appearances and staggering gait, frequently becoming exhausted and assuming a recumbent position. Many were seen to have a swelling in the inter-maxillary spaces and the conjunctival mucosa was pale wherever it was observed. On the following day, we returned to the farm and killed a lamb, that was very weak, by bleeding from the carotids. Only a small amount of blood flowed from the animal. Post-mortem examination showed almost identical conditions with those found in the other case. We decided that the stomach worm was responsible for the trouble, and that probably the worms had been introduced in the sheep bought from the stock buyer. Mr. M——— was advised to rotate pastures and have Dr. Olley treat the lambs with turpentine.

On July 28th, we visited the farm of Mr. G———, Cascade township, Kent county. He had lost 20% of a flock of about 50 lambs and breeding ewes. Had kept sheep for twelve years on the same pastures and had lost none before. Had bought sheep of a stock buyer a few months previously. We found his sheep in a good clover meadow on dry up-land, with no low, wet places. They had just been brought from another dry up-land pasture. The sheep were in rather poor condition. Many appeared very weak, in fact, some of them were unable to go from the one pasture to the other. There was seen a considerable swelling in the inter-maxillary space in many of the sheep; pale conjunctival mucosa, and a slight nasal discharge in a few. An especially weak lamb was killed by bleeding from the throat and examined. There was a noticeable deficiency in the amount of blood that flowed from the carotids. The organs of the body were quite pale, but showed no other abnormalities.

The lungs contained blood inhaled while bleeding to death. Many of the bronchioles in the dorsal portion of both principal lobes of the lambs were filled with lung worms (Str. filaria); the abomasum contained an enormous number of the twisted stomach worm (Haemonchus contortus); the Caecum showed a few specimens of the whip worm (Tr. affinis) attached to the mucosa. A few small nodules caused by Oesoph. columbianum were found in the intestinal walls.

Mr. G——— decided to sell all his marketable lambs, and have Dr. Olley treat the remainder. It was learned from various sources that other farmers in the neighborhood of Caledonia had lost a great number of lambs.

REPORT ON INVESTIGATION OF CATTLE DISEASE NEAR KINDE, HURON COUNTY.

A letter, dated Sept. 17, 1909, from Mr. C. A. Tyler, Secretary State Live Stock Sanitary Commission, caused the director of the laboratory to request me to visit certain farms in the vicinity of Kinde, where there existed a peculiar disease in cattle. Mr. Tyler and Dr. Geo. Fichett of Caseville had examined these cattle, without making a diagnosis.

On Sept. 20th, I visited the farm of Mr. A——— G——— and found two cows suffering from the disease in question. These cows were four and five years of age, respectively, and had been pastured with three other cows and eight yearlings all summer, or until they became apparently sick, when they were removed to an adjacent field. All the cattle on this farm were thin, the two sick ones being appreciably more emaciated than the others. They were both able to walk about and tried to eat the extremely short grass in the pasture. They walked with stilted gate, seeming to brace themselves with the fore feet especially.

Nothing could be found abnormal in the anatomy or physiology of the locomatory apparatus from an external examination. In each case, the muzzle was beaded with sweat, the extremities appeared normally warm, the facial expression was listless, not evidencing any pain. The back was slightly arched, the coat rough and the skin very harsh, showing poor nourishment. There were numerous "horn flies" on the cows, in fact, there were places about the root of the tail and the escutcheon where scales of clotted blood showed the work of the "horn fly." Mr. G——— said the flies had been unusually bad this summer, (other farmers in different parts of "the thumb" report the unpleasant prevalence of this pest). The temperature of Mr. G——— sicker cow was 102° C. at 5 p. m. Respiration and pulse, normal, with no unusual respiratory sounds and only a slightly exaggerated jugular pulse. The milk secretion was scanty, but the milk appeared all right, and had served the useful purpose of raising a fine calf on account of the refusal of the owner to use the milk in his home. These cows had been fed sweet-corn stalks for several weeks and whole oats and ate fairly well. The owner reported the condition of the excretions normal, but from the appearances in the pasture the feces were rather hard and scanty. Water was pumped by hand for the cows and they were reported as drinking normally. The pasture in this neighborhood consists mostly of June grass. The soil is sandy in places and a heavy clay in other places.

Mr. J——— N——— had kept a cow, 4 years old, in the pasture with Mr. G———'s cattle during part of the summer, but the cow became sick like those of Mr. G——— and was taken home to the adjoining farm. She was fed a little better after this and recovered.

Mr. J——— S——— had a young cow that exhibited the same symptoms as found in the cows of Mr. G———. Her temperature was 101.8° F. Feces, quite firm and scanty. She was giving only small amount of milk. The farm of Mr. S——— was about one mile from Mr. G———'s.

We found nothing in the history or examination of these cows to enable us to make a positive diagnosis. It did not appeal to us as being an infectious disease or of a parasitical nature. The owners were unwilling to sacrifice one of the sick animals for a post-mortem, so the most valuable part of the examination had to be omitted.

Working upon the supposition that the weakened condition of the animals was the result of the drain upon the system by the "horn flies" and probably insufficient or innutritious or at least unbalanced diet, we advised a more liberal ration and more nourishing food.

It was suggested that the cows be given each one pound of salts and a ration of ground oats and peas with one pound of linseed meal twice daily.

HAEMOGLOBINURIA IN HORSES.

On Nov. 5, '09, I met Dr. Gohn at the farm of Mr. B———, six miles west of Laingsburg. Dr. Gohn called my attention to the case on this farm, because of its unusual nature, and because of the fact that he had attended, during that same week, a fatal case showing the same symptoms.

The fatal case was a three-year-old gelding that had done some work during the fall and then had been turned out on a swamp pasture. The colt was first noticed apart from the others in the pasture, and apparently, very weak. Dr. Gohn reported the colt very weak, walking with uncertain gait, crossing the legs frequently. The temperature was 102.6° F; the impulse of the heart on the chest wall could be detected high on the right side of the thorax; no jugular pulse; urine highly colored with blood, or blood pigment. The visible mucosae had a dirty yellowish appearance. No post-mortem was held.

The case on the farm of Mr. B——— was a two-year-old filly. She had been pasturing on the same swamp where the fatal case had been, only at the opposite side of the swamp, nearly a mile distant. On the day before our visit, she was noticed keeping apart from the other horses, and was brought to the barn. She was very weak, moving with great difficulty and crossing the legs frequently. Appetite, almost absent; temperature, 100.6°; pulse, 72, and heart beat very powerful, so that auscultation at almost any point over right side of thorax revealed the heart sounds; no jugular pulse; respirations, 15 per minute. The urine was highly colored with blood, or blood pigment. The visible mucosa were slightly yellow and bloodless. No diagnosis was made: prognosis very unfavorable. Dr. Gohn prescribed potassium iodide.

Blood and urine were collected in sterile test-tubes. Unfortunately, slides were not at hand for blood smears. Smears made from the

clotted blood showed the red corpuscles greatly crenated and deformed. However, such preparations are not a reliable source for blood examinations. The urine had the color of diluted defibrinated blood. Microscopic examinations of the urine showed numerous amorphous, granular masses having an amber color, probably originating from the red blood cells. No red blood cells could be found. No casts or any amount of epithelial cells were found in the urinary sediment. Albumen was abundant; sugar, absent.

We were expecting an early post-mortem on this case, but affairs took a different trend. On Nov. 7th, Dr. Gohn "found animal standing, to all appearances, comfortable,—temperature, 102.4°; pulse, 48; respiration, quiet; abdominal grove, gone; conjunctiva, not so yellow and showing delicate tracing of vessels; impact of heart, not audible on right, except at lower part; bowels had moved freely; urine, voided in considerable quantities, not so highly colored, but containing a great amount of solid matter, though it did not seem to settle to bottom of cup very quickly; appetite, good, and was quite active."

On Nov. 9th, Dr. Gohn stated: "I went to A——— Bros., where the colt had died eight days before. I found a two-year old; temperature, 101.2°; pulse, 42; respiration, 18; slightly swollen legs; urine very thick and yellow (the owner said it looked like pus), with a little trace of haemoglobin, I thought, in some sediment, after standing a few minutes. Undoubtedly, this colt had been slightly affected at the same time as the other, but had escaped the owner's notice. I did not know they had more than two colts on the marsh, but they had four." On the 13th, Mr. B———'s colt was very weak and urine about as described for Mr. A———'s second colt. Dr. Gohn says: "I have read of cases of poisoning from eating oleander leaves left with poor control of hind quarters."

Dr. Gohn sent some stalks of poke weed (Phytolacca decandra) which he found growing abundantly on the A——— marsh. We could find no literature that incriminated this weed in the production of the symptoms found in the cases here described. We failed to produce any bad effects in rabbits and guinea pigs fed this weed.

Dr. Gohn writes that he had heard of two other animals dying in the neighborhood with a similar condition of the urine.

A WASTING DISEASE OF HORSES AT IMLAY CITY.

The laboratory received a letter from Mr. W——— of Imlay City, March 28, '10, describing a peculiar condition to which his horses were subject, under certain conditions.

A visit was made to the farm of Mr. W——— near Imlay City, April 9, '10, after a correspondence that had failed to offer an explanation for the trouble. The farm consisted of about 40 acres of level but well-drained, productive land. The system of farming was an intelligent rotation which, aided by a small herd of short-horn cattle, maintained the fertility of the soil. The farm buildings were very sanitary and well constructed. The barn-yard was clean. Water was supplied in a wooden trough in the barn-yard from a well 17 feet deep, and about one rod outside the barn-yard. The drainage was found from the well and the water was apparently very good. It was used for household purposes and all the stock.

The horses were fed the best of timothy hay and either oats of the

best quality, or ground feed. According to the owner, he had kept all kinds of horses, both young and old for seven years, but if he gave them all the feed and water they wanted, they would become weak, lose flesh, the legs would swell greatly, and it would be impossible to get a reasonable amount of work from them. They always showed a loose condition of the bowels and the food passed them only partially digested. The urine would be dark in color, and the odor in the stables became unbearable. None of these horses during the seven years had died of this trouble for the owner had always disposed of them whenever they showed the symptoms described and it was his experience that under the changed ownership the horses invariably improved and soon assumed a normal condition. If, however, the horses were returned to the affected farm, the trouble would soon manifest itself.

The horses were always in better condition when on pasture in the summer, although the same water was used, while a return to stable feed was invariably attended by a relapse. It was found that by restricting the amount of water allowed each horse to one pailful morning and night the trouble might be held in abeyance. The horses would not keep in the best condition even on this regimen, but if they were allowed water ad libitum for several days the trouble would return. It was not known that any similar cases ever occurred in the neighborhood.

An analysis had been made of the water without finding anything to condemn it. We do not know the nature of the analysis. Different veterinarians had prescribed symptomatic treatment with palliative but transient effects.

We were unable to discover any clue as a result of our visit. The owner appeared to be a careful and liberal stock feeder. Previous to the seven years of trouble, he maintained that he and his father had always kept horses on this same farm in the best of condition. Just before the trouble began, the old barn was replaced by the present structure and the water trough was first used at that time. Another well had been dug, but the trouble continued.

It was advised that the stables be carefully disinfected, and that the wooden trough be replaced by a new galvanized iron tank. This was done, but a letter received June 1st, 1910, reported no change in the condition of the horses.

A sample of the water taken from the trough showed only a few bacteria per ccm., one of which, a yellow staphylococcus, was not pathogenic for guinea pigs.

COMMERCIAL FEATURE OF THE LABORATORY.

In order to remove any tinge of commercialism from the research workers, the filling of orders has been placed in the hands of one assistant. This has proved a very satisfactory plan in the hands of Miss Rademacher, who has been exceedingly faithful in following the work of keeping the cultures in suitable condition, filling orders, and following the reports. It is with deep gratitude that I mention this because of the large amount of routine and burdensome details involved.

Very respectfully,

CHARLES E. MARSHALL,
Bacteriologist.

East Lansing, June 30, 1910.

REPORT OF THE CHEMIST.

Director Shaw:

I herewith submit the following report of the work of the Chemical Division for the year ending June 30th, 1910.

It is with the greatest satisfaction that I record the removal of the Division into the new laboratories in the Agricultural Building, at the beginning of the current year. The laboratories are located on the third floor of the north wing of the building and have a total floor space of 3,973 square feet. See plate on page 44.

Room 301, 25x26 ft., is a research laboratory devoted to soil chemistry and is in charge of Mr. Robinson. There is a small dark room for photographic work in connection with this laboratory. Room 302 is the library and stenographer's office. The current numbers of the following journals are kept on the shelves: Journal of the American Chemical Society, Journal of Industrial and Engineering Chemistry, Abstract Journal, Journal of Physical Chemistry, Zeitschrift für Physiologische Chemie, Die landwirtschaftlichen Versucho-Stationen and handwirtschafliche Jahrbücher. Room 302-1 is the private office of the chemist. Room 303, 17x19 ft., is the private laboratory of the chemist and is also devoted to research work in soil chemistry. Room 304, 29x34 ft., is the general laboratory for all analytical work and is in charge of Mr. Winter. Room 304-1, 18x18 ft., is a laboratory equipped exclusively for making nitrogen determinations. Room 304-2, 15x28 ft. is the general stock room. The air pump supplying compressed air and vacuum for all the laboratories is set up in this room. Room 305, 8x20 ft., is a general utility room for preparing samples, unpacking boxes, etc.

The laboratory desks, hoods, cases, etc., were made in Lansing and are very satisfactory. They are made of weathered oak and the desk tops are made of maple plank cut in three inch strips, glued together and finished black with an acid proof stain. The bottoms of the hoods, two desk tops and all the sinks are made of Alberene stone. All of the laboratories are supplied with gas, hot and cold water, air, vacuum, high pressure steam and electricity.

Mr. Chas. S. Robinson, M. S., a graduate of the University of Michigan was appointed research chemist to fill the vacancy caused by the resignation of Dr. S. L. Jodidi. Mr. Robinson began his duties Sept. 1st, 1909. Mr. Chas. B. Collingwood resigned as assistant chemist Oct. 1st, 1909, but the vacancy was not filled until Feb. 15th, 1910, when Mr. Orrin B. Winter, A. B., also a graduate of the University of Michigan, was appointed. Mr. Grover J. Secord severed his connection with the division March 1st, and Mr. Clarence J. Clippert, B. S., has been engaged for one year.

It is the opinion of the writer that the fertilizer law should be changed at the next session of the legislature.

Some of the manufacturers are wilfully misbranding their fertilizers in order to mislead the purchasers.

Acid phosphates made from rock phosphate are often branded

"Soluble Bone Phosphate" and dissolved rock blackened with lamp black or animal charcoal is sold as "Bone Black Fertilizer."

The nitrogen in mixed fertilizers comes from many sources and varies to a considerable extent in availability. Many states are now requiring the fertilizer manufacturer to properly brand his goods and also to state the sources of the nitrogen, phosphoric acid and potash. It is recommended that our fertilizer law be amended to include these requirements.

The fertilizer experiment that was conducted on the Howarden farm at Edwardsburg was discontinued last fall, owing to the failure of the tenant to furnish reliable data. No report has been prepared of this work as, owing to an unfortunate series of circumstances, the data were not considered reliable. The original tenant left the farm during the second year of the experiment and during the third year a long drought in the late summer and fall ruined a part of the work of that year. Last fall there was another change in tenants. Notwithstanding these extremely adverse conditions, the results show that the addition of lime was generally beneficial and particularly so when added in conjunction with barnyard manure or complete fertilizer. In 1908 the amount of clover hay was increased from 1911 pounds per acre on the check plot to 3,859 pounds per acre where lime and complete fertilizer were used. The yield of wheat was increased the same year from 9 bushels 40 pounds per acre on the check plot to 31 bushels 50 pounds where lime and manure were used.

The experiment started last year in conjunction with the Horticultural Division, to determine the influence of commercial fertilizers upon the growth of the young fruit trees and grape vines, is being continued and in addition an experiment was started last fall, at Lawton, on the influence of cover crops and commercial fertilizers upon the grape industry, also a series of experiments this year upon fertilizers for potatoes.

The projects under the Adams fund have been continued, viz., a study of the organic nitrogenous compounds in soils, and the chemical factors rendering soluble the insoluble soil phosphates. The laboratory studies are being supplemented this year by plot experiments in the field.

Technical bulletin No. 4, "Organic Nitrogenous Compounds in Peat Soils" by S. L. Jodidi, was published during the year.

In closing this report I wish to express my thanks to you for your support and to commend most highly the work of my associates.

Very respectfully,

ANDREW J. PATTEN,

Chemist.

East Lansing, June 30, 1910.

REPORT OF FARM CROPS EXPERIMENTER.

Director R. S. Shaw, East Lansing, Mich.:

Dear Sir: I have the honor to submit the following report as Farm Crop Experimenter for the year ending June 30th, 1910.

The main line of investigation during the year has been that of plant breeding, which is covered by the following report made by Assistant F. A. Spragg, who has had immediate charge of the work.

CROP IMPROVEMENT.

For this work seeds have been gathered from all available sources. The Department of Agriculture has aided greatly by furnishing imported seeds. Other lots came from farmers, seedsmen and experiment stations of this country. These seeds are planted so as to give the individual plants the same conditions as to space, moisture, plant food and sunshine. Superior plants become mothers of small plots, and the best of these are increased and tested out on a comparative basis to determine yields. The object is to increase the most desirable ones and distribute them to farmers of the state.

Wheat. There are 170 plots of wheat. Of these 59 are 1-20 acre plots to determine yield, 6 are increase plots, 10 are beds or selection plots in the first year, 103 are from single selected plants of 1909.

Oats. There are 197 oat plots. Of these 65 are 1.30 acre yield plots, 62 are from single selected plants of 1909, 48 are beds or selection plots in their first year and others are larger increase plots. The yield and increase plots are from individual plants of 1906-7-8.

Barley. The barley work has been increased by the importation of 24 new lots. Eight of these are winter varieties. The winter barley ripens several weeks earlier than the spring barley and is therefore more likely to avoid the hot, dry weather of early summer. Seeds from selected plants from these lots will be used to start small plots next year and as soon as possible will be increased and tested out in the yield series. All of the new lots are planted in selection plots this year. Nine plots of spring barley are from single plants of 1909, 9 others are 1-20 acre yield plots originating in single plants of former years.

Field Beans. Selection plots were started in 1908 and from these 65 progenies were grown in 1909. None of these lots have been increased because of the presence of disease. Eighteen resistent plants furnished seed for as many progeny rows for 1910. These are all pea beans. Selection rows of 6 other varieties of white beans are included for the first time this year. A number of colored beans are included in the work of 1909. Of these only one variety has been continued in 1910 but other new ones are included.

Cowpeas. The lines of work that were reported for last year are all being continued in a small way. A few of the more promising strains are being increased.

Soy Beans. Only one lot is being increased in 1910. Numerous other lots may be increased later if found desirable.

Timothy. A progeny nursery was set out in the spring of 1910. Individual notes are being continued in the original nursery that the value of several of these plants may be more definitely known.

Clover. The work reported last year is being continued. A small nursery has been set out from the Russian types. An ice-sheet covered the June clover nursery in February, 1910, killing two-thirds of the plants and assisting in making a more vigorous selection.

Alfalfa. The nurseries contain individual alfalfa plants from 124 different sources of seed. These came from widely separated parts of the world. They are being used to discover especially high producers of hay and seed. As Michigan is not producing alfalfa seed commercially, necessitating alfalfa growers to go outside of the state for unadapted seed, an attempt is being made to develop a strain of alfalfa which will produce seed abundantly, as well as satisfactory yields of hay. The third generation nursery along these lines has recently been planted. It is hoped to further increase the hay production from the selection of a few extremely high producers of hay that have not produced seed as yet.

FERTILITY STUDIES.

On account of the recent organization of this department, there are few experiments of long standing aside from the above on which to report.

The Davenport fertility and rotation experiment will be discontinued this season. The plots in this experiment were cropped uniformly for five years before the beginning of the experiment proper to determine the differences in the fertility of the soil. Then for 10 years, 1896-1905, the plots received different applications of manure and various fertilizers and different methods of culture and cropping. For the past five years the treatment has been the same so as to discover the effect of different treatments on the fertility of the soil. The fertility work at the station will not, however, be discontinued. Another experiment aimed at practical fertility problems and containing over 100 plots has already been started and was this year planted to oats to determine the fertility of the different plots.

VARIETY TESTS OF CORN.

No work is being done during the present season in the breeding of corn for the reason that practically no data is available as to which are the most promising varieties to be used as foundation stocks in this work. Variety tests including about thirty varieties of corn are, however, being conducted at the experiment station and at four other points, namely, Manchester, Washtenaw county; Cooper, Kalamazoo county; near Clare in Isabella county; and at Swan Creek, Saginaw county. The varieties being tested include some of the best Michigan grown corns the department has been able to find, also a small number of improved varieties from Ohio, Wisconsin and Minnesota. Doubtless there are other well adapted Michigan corns that may be included in the test another year. At the present writing, these experiments, with one exception, indicate that a fair comparison may be had between the several sorts and should furnish valuable information as to the most

promising varieties for breeding and the best varieties for growing in different sections of our state.

EXTENSION WORK.

The department has done considerable extension work during the past year in assisting farmers in the introduction of alfalfa, in visiting Granges, in judging at corn shows and addressing farmers at various farmer's meetings, institute trains, etc. The field for extension work in farm crops is almost unlimited and there is a splendid opportunity for the college to meet the practical needs of the farmers along this line as soon as a sufficient force can be had to undertake the work.

Very respectfully,

V. M. SHOESMITH,

Farm Crops Experimenter.

East Lansing, June 30th, 1910.

REPORT OF THE HORTICULTURIST.

To the Director:

Sir: The horticultural work of last year was continued and new work was inaugurated as time and funds permitted. A special effort is being made to determine the value of cover crops in combination with chemical fertilizer to maintain the fertility in vineyards,—this work is with the assistance of the Chemical Division and is being conducted in three vineyards at Lawton. The keeping qualities of apples handled in different ways is being tested. The comparative merits and values of the different spraying mixtures have received attention.

A bulletin on "Spray and Practice Outlines for Fruit Growers" was prepared in cooperation with R. H. Pettit of the Division of Entomology.

A greenhouse for experimental work is needed, as much work with greenhouse crops should be started and this industry is a large one in Michigan. It is hoped that a suitable house can be erected soon.

Preparations have been under way for a series of bulletins to supply general information on the culture of fruit and vegetable crops.

I wish to record my appreciation of the services of Assistant Horticulturist C. P. Halligan and to you for encouragement and support in the work of the Division.

Respectfully submitted,

H. J. EUSTACE,

Horticulturist.

East Lansing, Mich., June 30, 1910.

REPORT OF SOIL PHYSICIST.

Director R. S. Shaw:

Dear Sir: During the year just closing attention has been given to the lines indicated in our report a year ago. A continuous record is being kept of the temperature of the air at the average height of ripening grain and of the soil at six inches below the surface. A series of records is also being made of temperature of soil at different depths with different conditions of surface.

Time has been given to the inauguration of the cooperative experiment mentioned in another report.

In the laboratory preliminary work has been done in the way of developing certain methods of soil study, the further report of which is inadvisable at this time. It is hoped that as our laboratory and equipment is completed and our other work better provided for that it will be possible to give more attention to this work.

Very respectfully,
JOS. A. JEFFERY,
Soil Physicist.

East Lansing, Michigan, June 30, 1910.

REPORT OF THE ENTOMOLIGIST.

Director R. S. Shaw, East Lansing, Michigan:

Dear Sir: Following is a brief report of the work of the Division of Entomology for the year ending June 30, 1910.

The season thus far has been marked by great numbers of cut-worms.

During the year, Bulletin 258, "Insects of Field Crops," was published, besides one written in conjunction with Professor H. J. Eustace of the Department of Horticulture. The latter is Special Bulletin 51, entitled "Spray and Practice Outline for Fruit Growers." Besides this a press bulletin on the tussock-moth was written.

About the last of March Mr. Yothers left to take a position in Washington State College and Miss Eugenia McDaniel was engaged to take his place.

Considerable work has been done on the fungus diseases of insects, a number of new forms having been grown in culture. The ill-health of the writer has, however, proved a serious handicap. Dr. Shafer's problem on Insecticides has gone steadily forward and his progress is gratifying.

The added room made available by the completion of the Agricultural Building has made it possible to fit up a fine laboratory for research in the basement, besides helping in many other ways.

Yours respectfully,
R. H. PETTIT,
Entomologist.

East Lansing, June 30, 1910.

METEOROLOGICAL TABLES.

Meteorological observations for the month of January, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	13	20	29.35	29.30	19	11	Cloudy	s	0.0	0.0
2	16	30	29.28	29.16	30	16	Cloudy	s	.02	.25
3	36	36	29.08	29.13	38	28	Pt. cloudy	s	0.0	0.0
4	38	45	28.80	28.80	48	32	Cloudy	s	.03	0.0
5	35	33	28.85	28.86	45	32	Cloudy	s	.09	0.0
6	7	0	29.06	29.41	33	0	Pt. cloudy	n w	0.0	0.0
7	3	13	29.60	29.56	13	0	Pt. cloudy	n e	0.0	0.0
8	14	24	29.42	29.49	24	8	Pt. cloudy	s	0.0	0.0
9	25	30	29.19	29.08	30	20	Cloudy	s w	trace.	0.0
10	33	32	29.07	29.00	33	29	Cloudy	w	.03	0.0
11	15	32	29.37	29.33	32	12	Cloudy	n	0.0	0.0
12	8	10	29.34	29.46	32	8	Clear	w	.03	.3
13	8	19	29.48	29.31	20	4	Pt. cloudy	s	0.0	0.0
14	23	31	29.08	29.15	31	18	Cloudy	s	trace.	0.0
15	23	16	29.40	29.55	31	16	Pt. cloudy	n	0.0	0.0
16	14	18	29.46	29.27	18	14	Pt. cloudy	w	0.0	0.0
17	19	27	29.29	29.41	30	17	Clear	n w	0.0	0.0
18	12	20	29.56	29.36	27	12	Clear	n e	trace.	0.0
19	27	31	29.04	29.19	34	18	Pt. cloudy	s w	0.0	0.0
20	26	32	29.26	29.07	32	22	Cloudy	s w	0.0	0.0
21	42	46	29.00	29.05	48	31	Pt. cloudy	s	.01	0.0
22	49	52	29.05	28.99	52	44	Cloudy	s	.15	0.0
23	55	60	28.89	28.92	56	50	Cloudy	s	0.50	0.0
24	56	38	28.86	29.02	56	38	Clear	s e	0.0	0.0
25	32	32	29.11	29.15	39	32	Clear	w	0.0	0.0
26	28	34	29.28	29.08	40	28	Clear	w	0.0	0.0
27	33	30	28.76	28.97	34	29	Pt. cloudy	w	0.0	0.0
28	21	31	29.04	28.86	32	20	Clear	s e	0.0	0.0
29	29	28	29.26	29.18	31	27	Cloudy	e	.90	9.0
30	19	11	28.57	28.95	28	11	Cloudy	n	.40	4.0
31	3	0	29.31	29.53	11	−1	Clear	w	0.0	0.0
Sum	762	857	904.19	904.19	1,023	627			2.16	13.55
Mean	24.6	27.6	29.167	29.167	33.1	20.2				

Meteorological observations for the month of February, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	0	20	29.50	29.30	20	−11	Pt. cloudy	s w	0.0	0.0
2	21	31	29.31	29.22	33	16	Clear	s w	0.0	0.0
3	23	29	29.07	28.98	31	22	Cloudy	e	0.0	0.0
4	26	45	28.76	28.69	45	25	Pt. cloudy	s	0.0	0.0
5	45	47	28.46	28.14	47	26	Cloudy	s	0.18	0.0
6	28	48	28.63	28.84	49	27	Pt. cloudy	s	0.25	2.0
7	29	46	29.00	29.01	48	29	Cloudy	s	0.0	0.0
8	26	18	29.20	29.19	46	17	Pt. cloudy	s	0.0	0.0
9	23	40	28.83	28.34	40	18	Cloudy	s e	0.27	2.75
10	13	17	28.36	28.60	40	13	Cloudy	s	0.0	0.0
11	17	23	28.90	29.13	40	15	Pt. cloudy	w	0.02	0.25
12	23	41	29.00	28.94	41	17	Cloudy	s	0.0	0.0
13	19	23	29.12	29.29	41	18	Cloudy	n e	trace.	0.0
14	22	20	29.19	29.26	23	16	Pt. cloudy	n	0.01	0.1
15	19	15	29.22	29.21	23	13	Cloudy	n	0.05	0.5
16	17	15	29.04	29.06	42	11	Cloudy	n	0.40	4.0
17	17	27	29.08	29.13	34	9	Pt. cloudy	w	0.0	0.0
18	25	39	29.11	28.82	39	15	Pt. cloudy	s	0.0	0.0
19	37	35	28.57	28.47	39	27	Cloudy	s w	0.52	0.0
20	31	32	28.67	28.87	39	30	Cloudy	w	trace.	0.0
21	32	38	28.95	29.01	38	29	Pt. cloudy	s w	0.0	0.0
22	31	37	29.20	29.22	40	28	Clear	s e	0.0	0.0
23	33	38	28.85	28.58	38	32	Cloudy	s e	0.51	0.0
24	33	26	28.45	28.83	42	26	Cloudy	w	0.10	0.2
25	15	22	29.22	29.22	28	15	Pt. cloudy	w	0.0	0.0
26	28	39	28.91	28.79	40	26	Clear	s w	0.0	0.0
27	28	28	28.87	28.93	40	28	Cloudy	n w	0.04	0.04
28	10	24	29.10	29.10	28	8	Clear	s w	0.0	0.0
Sum	671	865	810.57	810.17	1,054	539			2.36	10.3
Mean	24.0	30.9	28.949	28.935	37.6	19.2				

Meteorological observations for the month of March, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	29	38	28.92	28.80	41	23	Clear	s	0.0	0.0
2	28	34	28.91	28.77	38	27	Clear	e	0.0	0.0
3	33	29	28.56	28.92	34	29	Pt. cloudy	n	0.20	1.7
4	21	22	28.98	28.94	29	18	Clear	n w	0.0	0.0
5	17	34	28.99	28.92	34	15	Clear	w	0.0	0.0
6	32	39	28.83	28.77	39	30	Cloudy	s	0.01	0.0
7	33	34	28.98	29.22	39	30	Pt. cloudy	w	0.0	0.0
8	33	34	29.22	29.06	34	29	Cloudy	s e	0.0	0.0
9	32	33	28.72	28.51	34	30	Cloudy	e	0.17	0.0
10	34	28	28.50	28.99	33	24	Cloudy	w	0.0	0.0
11	21	26	29.40	29.46	28	20	Clear	n	0.0	0.0
12	27	33	29.43	29.22	33	23	Pt. cloudy	e	0.0	0.0
13	29	37	29.11	28.98	33	27	Clear	n e	0.0	0.0
14	29	30	29.04	29.11	37	28	Pt. cloudy	n w	0.05	0.0
15	24	32	29.26	29.15	32	21	Pt. cloudy	n w	0.0	0.0
16	27	20	28.10	28.88	32	20	Cloudy	w	0.10	0.0
17	19	22	29.12	29.16	22	15	Cloudy	n	0.0	0.0
18	22	34	29.21	29.03	34	15	Pt. cloudy	s	trace.	trace.
19	35	34	28.84	28.96	34	32	Cloudy	n	0.0	0.0
20	33	29	29.09	29.09	34	25	Pt. cloudy	n e	0.0	0.0
21	29	26	29.18	29.25	29	17	Clear	n	0.0	0.0
22	24	35	29.37	29.35	35	19	Clear	n	0.0	0.0
23	31	39	29.36	29.08	39	26	Clear	s	0.0	0.0
24	40	33	28.68	28.46	40	32	Cloudy	s	0.21	1.0
25	30	30	28.48	28.64	33	37	Pt. cloudy	n w	0.0	0.0
26	30	42	28.67	28.53	42	24	Cloudy	s	0.09	0.0
27	36	33	28.46	28.58	42	32	Pt. cloudy	s w	trace.	trace.
28	32	33	28.60	28.64	36	27	Pt. cloudy	w	0.07	0.0
29	33	34	28.70	28.75	34	26	Cloudy	w	trace.	trace.
30	28	36	28.85	29.05	36	26	Cloudy	n w	trace.	trace.
31	33	40	29.24	29.21	45	31	Clear	w	0.0	0.0
Sum	904	1,003	896.80	897.48	1,079	768				
Mean	29.2	32.4	28.929	28.951	35.0	24.8			0.90	2.7

Meteorological observations for the month of April, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	35	43	29.19	28.06	43	27	Clear	w	0.0	0.0
2	34	43	28.96	28.83	43	33	Cloudy	n w	0.0	0.0
3	35	40	28.72	28.72	50	33	Cloudy	n w	0.06	0.0
4	39	45	29.04	28.85	45	29	Clear	n e	0.0	0.0
5	48	66	28.75	28.85	66	39	Cloudy	s	0.0	0.0
6	54	62	28.92	28.77	70	51	Cloudy	s	0.20	0.0
7	40	41	28.61	29.03	62	38	Pt. cloudy	w	0.22	0.0
8	33	32	29.26	29.11	41	29	Cloudy	s w	trace.	trace.
9	28	25	29.01	29.16	32	24	Cloudy	n w	0.15	0.0
10	24	30	29.37	29.38	32	24	Pt. cloudy	n	0.0	0.0
11	31	47	29.41	29.10	50	17	Clear	s	0.0	0.0
12	52	61	28.98	28.76	61	48	Pt. cloudy	s	0.01	0.0
13	34	36	28.76	29.11	61	31	Pt. cloudy	n e	0.19	0.0
14	34	42	29.32	29.26	49	26	Clear	s e	0.0	0.0
15	42	52	29.31	29.24	53	42	Clear	s e	0.0	0.0
16	44	55	29.20	29.12	63	38	Pt. cloudy	e	0.18	0.0
17	50	57	29.26	29.23	64	43	Clear	e	0.30	0.0
18	58	58	28.90	28.94	70	49	Pt. cloudy	s	0.25	0.0
19	40	39	28.93	29.14	58	38	Cloudy	n	0.34	0.0
20	35	47	29.13	29.03	52	30	Pt. cloudy	e	0.0	0.0
21	40	40	28.67	28.66	58	34	Pt. cloudy	s	0.39	0.0
22	40	44	28.90	28.92	53	36	Pt. cloudy	s	0.0	0.0
23	35	35	29.09	29.21	45	29	Clear	n w	0.0	0.0
24	32	42	29.39	29.25	45	28	Cloudy	s	0.07	0.0
25	47	42	29.00	29.12	54	17	Pt. cloudy	e	0.5	0.0
26	37	50	29.17	29.00	56	28	Pt. cloudy	s	0.02	0.0
27	50	39	28.67	29.03	52	38	Pt. cloudy	n	0.25	0.0
28	32	33	29.32	29.20	46	27	Cloudy	s e	0.07	0.0
29	34	34	28.85	28.64	38	30	Cloudy	s e	1.75	4.0
30	35	39	28.42	28.60	46	32	Cloudy	s	1.45	0.0
Sum	1,166	1,303	870.23	870.83	1,558	1,019			5.96	4.0
Mean	38.9	47.8	29.008	29.028	51.9	33.6				

Meteorological observations for the month of May, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	36	32	28.59	28.76	41	24	Pt. cloudy	s w	0.05	0.5
2	32	38	28.83	28.97	42	23	Pt. cloudy	s w	0.03	0.3
3	38	39	28.97	28.98	45	32	Pt. cloudy	w	0.11	0.0
4	41	50	28.96	28.84	56	31	Clear	w	0.0	0.0
5	52	72	28.75	28.68	78	39	Clear	s w	0.0	0.0
6	67	63	28.81	28.84	79	60	Clear	s	0.35	0.0
7	47	57	29.13	29.12	65	41	Clear	s	0.04	0.0
8	53	62	29.03	28.92	68	43	Pt. cloudy	s	0.0	0.0
9	59	49	28.73	28.90	63	47	Cloudy	s w	0.50	0.0
10	40	52	28.96	29.08	56	40	Pt. cloudy	n	0.06	0.0
11	46	56	29.25	29.24	62	35	Clear	n w	0.0	0.0
12	52	61	29.30	29.08	67	42	Clear	s	0.0	0.0
13	57	67	29.06	28.97	75	52	Cloudy	s	0.0	0.0
14	60	65	29.00	28.95	68	58	Cloudy	s	0.28	0.0
15	62	65	28.76	28.65	79	54	Pt. cloudy	s	0.53	0.0
16	48	51	28.78	28.87	68	24	Pt. cloudy	n w	0.0	0.0
17	50	46	28.98	29.11	60	42	Clear	w	0.0	0.0
18	47	58	29.18	29.16	67	42	Pt. cloudy	e	0.0	0.0
19	58	59	29.15	29.20	67	46	Clear	s e	0.0	0.0
20	54	59	29.21	29.16	69	45	Clear	n e	0.0	0.0
21	52	59	29.15	29.15	68	49	Pt. cloudy	e	0.0	0.0
22	50	.....	29.20	.....	.....	.....	Pt. cloudy	e	0.0	0.0
23	60	60	29.21	29.15	71	47	Pt. cloudy	e	0.0	0.0
24	59	60	29.25	29.25	71	49	Clear	e	0.0	0.0
25	60	60	29.28	29.24	71	46	Clear	e	0.0	0.0
26	55	63	29.28	29.17	73	50	Pt. cloudy	s e	0.0	0.0
27	56	59	29.03	28.98	70	56	Cloudy	s w	0.43	0.0
28	53	63	29.02	29.07	70	50	Clear	w	0.0	0.0
29	64	72	29.18	29.13	81	49	Clear	w	0.0	0.0
30	70	66	29.08	29.03	79	58	Pt. cloudy	s e	0.04	0.0
31	65	71	29.11	29.12	80	60	Pt. cloudy	s e	0.02	0.0
Sum	1,643	1,739	900.22	870.79	2,009	1,334	.....	.....	2.44	0.8
Mean	53.0	57.9	29.039	29.026	67.0	44.5	.....	.....	.....	.....

Meteorological observations for the month of June, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	62	67	29.18	29.18	75	56	Pt. cloudy	e	0.56	0.0
2	62	71	29.22	29.14	79	59	Cloudy	s	0.0	0.0
3	65	72	29.09	29.02	79	63	Cloudy	s e	0.3	0.0
4	63	66	28.91	29.01	73	57	Cloudy	n	0.46	0.0
5	67	67	29.02	29.16	76	57	Pt. cloudy	n	0.0	0.0
6	64	59	29.24	29.21	78	50	Pt. cloudy	n e	0.04	0.0
7	58	43	29.25	29.33	61	52	Cloudy	e	0.44	0.0
8	55	56	29.33	29.26	59	51	Cloudy	e	0.08	0.0
9	57	65	29.22	29.18	72	52	Cloudy	e	0.01	0.0
10	59	.....	29.17	29.21	.....	.....	Cloudy	n e	0.51	0.0
11	.....	.....	29.30	29.25	70	49	Pt. cloudy	n	0.0	0.0
12	62	69	29.22	29.11	75	52	Pt. cloudy	s	0.0	0.0
13	64	73	28.97	28.89	78	58	Cloudy	s	0.25	0.0
14	56	57	29.09	29.26	73	55	Cloudy	n w	0.0	0.0
15	52	62	29.42	29.39	72	42	Clear	s w	0.0	0.0
16	61	70	29.34	29.12	76	48	Clear	s w	0.0	0.0
17	62	62	29.04	29.19	71	60	Pt. cloudy	n w	0.24	0.0
18	52	62	29.40	29.37	68	42	Clear	n	0.0	0.0
19	55	56	29.37	29.28	76	45	Pt. cloudy	w	0.0	0.0
20	75	73	29.34	29.40	82	54	Pt. cloudy	w	0.0	0.0
21	75	71	29.32	29.29	84	54	Cloudy	s w	trace.	0.0
22	69	78	29.22	29.12	84	65	Cloudy	w	0.0	0.0
23	75	78	29.11	29.04	85	68	Pt. cloudy	w	0.07	0.0
24	75	73	29.04	29.05	81	65	Pt. cloudy	w	0.0	0.0
25	67	75	29.10	29.10	82	63	Pt. cloudy	s w	0.17	0.0
26	67	76	29.24	29.23	84	62	Clear	s	0.0	0.0
27	78	76	29.22	29.16	88	66	Clear	s e	trace.	0.0
28	76	79	29.23	29.24	88	65	Clear	n e	0.0	0.0
29	78	71	29.33	29.29	83	64	Clear	n e	0.0	0.0
30	71	80	29.29	29.17	88	55	Clear	w	0.0	0.0
Sum	1,882	1,987	876.23	875.65	2,240	1,631	.....	.....	2.86	0.0
Mean	62.7	66.2	29.208	29.188	77.2	56.2	.....	.....	.....	.....

Meteorological observations for the month of July, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rainfall, inches.	Snow fall, in inches.
1	72	76	29.16	29.11	85	66	Clear	w	0.0	0.0
2	69	69	29.14	28.87	84	55	Clear	s w	0.47	0.0
3	59	62	29.12	29.14	70	53	Clear	n	0.0	0.0
4	61	64	29.23	29.19	71	46	Clear	n	0.0	0.0
5	66	66	29.24	29.20	76	49	Pt. cloudy	w	0.0	0.0
6	68	71	29.20	29.20	81	52	Clear	ne	0.0	0.0
7	68	70	29.26	29.25	80	55	Clear	n	0.0	0.0
8	71	73	29.24	29.15	83	50	Clear	e	0.0	0.0
9	72	78	29.14	29.09	87	50	Clear	s	0.0	0.0
10	73	79	29.10	29.08	87	65	Clear	s w	0.0	0.0
11	73	73	29.07	28.92	86	67	Clear	s	0.0	0.0
12	77	74	28.84	28.87	88	67	Pt. cloudy	s w	0.0	0.0
13	65	75	29.02	29.04	89	61	Pt. cloudy	s w	0.0	0.0
14	72	78	29.11	29.11	89	62	Clear	n w	0.0	0.0
15	75	73	29.13	29.08	88	63	Cloudy	w	0.59	0.0
16	78	71	29.10	29.13	79	59	Clear	w	0.0	0.0
17	64	70	29.27	29.17	78	50	Clear	n	0.0	0.0
18	62	69	29.15	29.29	75	60	Pt. cloudy	n	0.0	0.0
19	62	71	29.46	29.43	78	48	Clear	n w	0.0	0.0
20	66	70	29.51	29.44	81	50	Cloudy	w	0.0	0.0
21	78	75	29.41	29.17	84	50	Pt. cloudy	s	0.0	0.0
22	71	68	29.01	28.88	80	65	Cloudy	w	0.60	0.0
23	60	68	28.87	29.08	75	58	Pt. cloudy	n	0.37	0.0
24	64	71	29.81	29.25	78	53	Clear	n w	0.0	0.0
25	66	74	29.38	29.33	83	54	Clear	w	0.0	0.0
26	70	72	29.30	29.19	81	61	Clear	s e	0.0	0.0
27	72	74	29.20	29.18	83	60	Clear	s e	0.0	0.0
28	73	76	29.22	29.18	88	64	Pt. cloudy	s	0.37	0.0
29	78	82	29.22	29.14	87	72	Pt. cloudy	s w	0.02	0.0
30	74	75	29.19	29.14	84	66	Clear	n e	0.04	0.0
31	67	71	29.12	29.12	88	63	Pt. cloudy	s	0.10	0.0
Sum	2,146	2,238	904.61	903.42	2,546	1,793			2.56	0.0
Mean	69.2	72.2	29.181	29.143	82.2	57.8				

Meteorological observations for the month of August, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rainfall, inches.	Snow fall, in inches.
1	73	65	29.20	29.24	80	60	Pt. cloudy	s	.13	0.0
2	61	72	29.37	29.38	81	61	Clear	n	0.17	0.0
3	71	71	29.38	29.33	86	61	Clear	s	0.0	0.0
4	69	71	29.29	29.16	78	67	Cloudy	s	0.16	0.0
5	66	72	29.24	29.24	82	62	Clear	n e	0.0	0.0
6	69	78	29.30	29.30	87	57	Clear	n	0.0	0.0
7	77	79	29.40	29.36	91	64	Clear	n w	0.0	0.0
8	77	80	29.36	29.23	90	61	Clear	w	0.0	0.0
9	74	76	29.25	29.26	83	71	Clear	e	0.14	0.0
10	64	65	29.35	29.38	77	59	Clear	n e	0.0	0.0
11	62	64	29.38	29.25	75	56	Pt. cloudy	e	0.01	0.0
12	60	73	29.20	29.15	79	56	Pt. cloudy	e	0.07	0.0
13	70	75	29.19	29.15	84	61	Clear	e	0.0	0.0
14	68	73	29.17	29.08	76	65	Cloudy	e	0.0	0.0
15	73	76	29.00	28.93	87	69	Clear	s w	0.0	0.0
16	73	71	28.90	28.90	83	63	Pt. cloudy	n w	trace.	0.0
17	64	69	28.93	28.88	76	57	Clear	w	0.0	0.0
18	65	73	28.94	28.90	82	55	Pt. cloudy	n w	0.0	0.0
19	71	73	29.03	29.02	85	54	Clear	w	0.0	0.0
20	64	62	29.16	29.27	73	56	Pt. cloudy	n	0.27	0.0
21	63	65	29.43	29.30	76	46	Clear	e	0.0	0.0
22	65	68	29.47	29.38	80	50	Clear	s w	0.0	0.0
23	66	76	29.39	29.31	87	55	Clear	s	0.0	0.0
24	72	78	29.33	29.28	90	63	Clear	s	0.0	0.0
25	78	76	29.30	29.26	93	66	Pt. cloudy	w	0.03	0.0
26	73	78	29.27	29.25	89	70	Clear	w	0.0	0.0
27	73	69	29.28	29.22	89	58	Cloudy	s	0.01	0.0
28	71	76	29.12	29.10	87	65	Pt. cloudy	e	0.62	0.0
29	69	59	29.36	29.40	77	57	Clear	n	0.0	0.0
30	59	62	29.46	29.28	74	44	Clear	s e	0.00	0.0
31	60	54	29.10	29.17	76	54	Pt. cloudy	n	0.0	0.0
Sum	2,119	2,199	906.55	905.36	2,553	1,843			1.61	0.0
Mean	68.4	70.9	29.244	29.205	82.4	59.5				

Meteorological observations for the month of September, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rainfall, inches.	Snow fall, in inches.
1	48	63	29.37	29.33	67	33	Clear	n	0.0	0.0
2	54	62	29.33	29.23	73	37	Pt. cloudy	w	0.0	0.0
3	61	59	29.20	29.02	65	55	Cloudy	s	0.0	0.0
4	61	66	28.97	29.17	69	57	Pt. cloudy	s	0.0	0.0
5	60	67	29.42	29.36	69	46	Clear	w	0.01	0.0
6	56	59	29.31	29.20	72	46	Clear	w	0.0	0.0
7	56	59	29.32	29.37	75	50	Clear	n e	0.0	0.0
8	59	69	29.37	29.30	81	46	Clear	s	0.0	0.0
9	66	65	29.27	29.13	70	61	Clear	s e	0.0	0.0
10	62	68	29.12	29.20	77	58	Clear	w	0.0	0.0
11	59	64	29.38	29.38	78	52	Clear	n e	0.0	0.0
12	59	70	29.38	29.29	81	52	Clear	e	0.0	0.0
13	70	79	29.30	29.27	89	63	Clear	s	0.0	0.0
14	74	79	29.30	29.24	89	68	Clear	s	0.0	0.0
15	62	60	29.27	29.36	79	59	Pt. cloudy	w	0.20	0.0
16	57	61	29.39	29.22	72	45	Clear	w	0.0	0.0
17	59	64	29.29	29.34	80	50	Clear	n	0.0	0.0
18	55	61	29.49	29.44	74	46	Clear	e	0.0	0.0
19	60	67	29.41	29.37	78	44	Clear	e	0.0	0.0
20	56	74	29.34	29.26	85	51	Clear	e	0.0	0.0
21	68	71	29.20	28.99	78	65	Pt. cloudy	s	0.0	0.0
22	67	67	28.83	28.98	72	62	Cloudy	s	0.31	0.0
23	57	63	29.06	29.28	68	52	Clear	n w	0.79	0.0
24	50	52	29.36	29.40	63	43	Clear	w	0.03	0.0
25	48	50	29.56	29.58	59	39	Clear	n	0.0	0.0
26	48	46	29.66	29.55	56	37	Clear	n e	0.0	0.0
27	43	47	29.51	29.35	60	38	Clear	n	0.0	0.0
28	44	50	29.25	29.06	57	37	Cloudy	w	0.0	0.0
29	50	48	28.94	29.05	59	45	Cloudy	n	0.15	0.0
30	45	50	29.11	29.16	54	40	Cloudy	n w	0.02	0.0
Sum	1,710	1,860	878.71	877.78	2,148	1,477			1.51	0.0
Mean	57.0	62.0	29.290	29.263	71.6	49.2				

Meteorological observations for the month of October, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	44	50	29.24	29.21	60	38	Pt. cloudy	n w	0.0	0.0
2	40	51	29.28	29.26	63	35	Clear	n	0.0	0.0
3	54	53	29.34	29.35	66	34	Clear	n	0.0	0.0
4	47	54	29.46	29.47	63	35	Pt. cloudy	n	0.0	0.0
5	45	55	29.57	29.51	68	37	Clear	n e	0.0	0.0
6	46	57	29.54	29.41	74	38	Clear	e	0.0	0.0
7	47	62	29.37	29.30	78	40	Clear	s	0.0	0.0
8	53	61	29.35	29.37	79	46	Clear	e	0.0	0.0
9	52	65	29.39	29.30	80	48	Clear	s e	0.0	0.0
10	58	58	29.16	28.76	76	50	Pt. cloudy	s e	0.09	0.0
11	47	42	28.76	28.74	62	42	Cloudy	w	0.0	0.0
12	32	30	28.76	28.88	45	22	Pt. cloudy	w	0.10	.50
13	30	36	28.97	28.92	36	28	Pt. cloudy	s w	0.0	0.0
14	32	39	28.86	28.80	46	26	Pt. cloudy	s w	0.5	0.0
15	35	37	28.89	28.95	46	30	Pt. cloudy	w	0.11	0.0
16	40	42	29.11	29.25	48	33	Pt. cloudy	w	0.04	0.0
17	44	44	29.46	29.48	51	38	Clear	w	0.0	0.0
18	35	42	29.55	29.64	50	34	Pt. cloudy	n	0.04	0.0
19	34	39	29.80	29.67	51	27	Clear	n w	0.0	0.0
20	35	48	29.60	29.29	55	30	Pt. cloudy	e	0.01	0.0
21	53	51	29.03	29.00	57	42	Cloudy	w	0.08	0.0
22	45	43	29.17	29.30	53	42	Cloudy	w	0.0	0.0
23	36	35	29.18	29.35	43	34	Cloudy	n	0.03	0.0
24	32	33	29.40	29.35	45	31	Clear	n w	0.0	0.0
25	32	47	29.25	29.05	47	31	Pt. cloudy	s	0.0	0.0
26	41	47	29.04	29.00	63	37	Clear	w	0.02	0.0
27	38	35	29.13	29.22	48	33	Clear	w	0.04	0.0
28	30	32	29.41	29.50	38	26	Clear	n w	0.0	0.0
29	28	38	29.55	29.39	39	21	Clear	e	trace.	0.0
30	44	55	29.29	29.17	69	35	Clear	s	0.0	0.0
31	55	60	29.20	29.17	73	49	Clear	s	0.0	0.0
Sum	1,284	1,441	907.11	906.06	1,772	1,092			0.71	0.50
Mean	41.4	46.5	29.262	29.228	57.2	35.2				

Meteorological observations for the month of November, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	53	54	29.13	28.95	62	49	Cloudy	s	0.18	0.0
2	48	47	28.93	29.18	63	44	Pt. cloudy	s w	0.17	0.0
3	43	46	29.20	28.97	56	38	Pt. cloudy	s w	0.0	0.0
4	42	45	29.17	29.37	52	39	Pt. cloudy	n w	0.0	0.0
5	40	43	29.52	29.53	48	38	Pt. cloudy	s	0.0	0.0
6	42	50	29.60	29.68	59	40	Pt. cloudy	e	0.0	0.0
7	51	56	29.50	29.48	61	43	Pt. cloudy	s	0.01	0.0
8	47	36	29.63	29.86	59	38	Pt. cloudy	n	0.06	0.0
9	33	39	29.84	29.71	51	30	Clear	e	0.0	0.0
10	47	57	29.50	29.37	60	34	Pt. cloudy	s	0.02	0.0
11	58	64	29.32	29.36	71	54	Pt. cloudy	s	0.0	0.0
12	57	47	29.53	29.50	65	46	Pt. cloudy	n	0.02	0.0
13	47	51	29.58	29.56	67	46	Pt. cloudy	s e	0.06	0.0
14	59	61	29.55	29.48	69	45	Pt. cloudy	s	0.04	0.0
15	38	39	29.65	29.67	62	35	Pt. cloudy	e	0.0	0.0
16	35	46	29.26	28.87	62	32	Cloudy	s	1.05	0.0
17	33	32	28.92	29.37	51	28	Cloudy	n w	0.0	0.0
18	29	31	29.56	29.43	34	28	Cloudy	w	0.0	0.0
19	33	44	29.19	28.97	49	30	Pt. cloudy	s w	trace.	trace.
20	45	51	28.86	28.88	53	31	Pt. cloudy	s	0.0	0.0
21	43	35	29.22	29.38	56	35	Cloudy	n	0.01	0.0
22	34	34	28.87	28.86	37	25	Cloudy	n	1.40	0.50
23	18	28	29.33	29.44	30	17	Pt. cloudy	n e	0.0	0.0
24	17	30	29.47	29.33	36	14	Clear	n e	0.0	0.0
25	30	35	29.30	29.36	46	24	Clear	w	0.0	0.0
26	34	44	29.51	29.47	54	30	Clear	s	0.0	0.0
27	40	52	29.43	29.40	63	36	Clear	s	0.0	0.0
28	54	37	29.40	29.57	58	36	Pt. cloudy	w	0.12	0.0
29	28	38	29.76	29.67	49	27	Clear	e	0.0	0.0
30	34	39	29.43	29.48	47	29	Clear	s e	0.0	0.0
Sum	1,212	1,301	881.16	881.15	1,630	1,041			2.74	0.50
Mean	40.4	42.7	29.372	29.372	54.3	34.7				

Meteorological observations for the month of December, 1909, at Agricultural College, East Lansing, Michigan.

Date.	Thermometer in open air.		Barometer reduced to freezing point.		Registering thermometers.		Character of day.	Prevailing wind direction.	Precipitation.	
	7 a. m.	7 p. m.	7 a. m.	7 p. m.	Max.	Min.			Rain and melted snow, in inches.	Snow fall, in inches.
1	30	42	29.30	29.20	52	28	Clear	e	0.0	0.0
2	36	40	29.23	29.16	50	34	Pt. cloudy	e	0.0	0.0
3	35	40	29.19	29.26	56	34	Pt. cloudy	n e	0.0	0.0
4	41	45	29.31	29.33	50	38	Pt. cloudy	s e	0.0	0.0
5	47	35	29.14	28.88	38	22	Pt. cloudy	s	0.02	0.0
6	24	38	29.33	29.35	38	20	Pt. cloudy	w	0.0	0.0
7	26	22	28.81	28.93	29	21	Pt. cloudy	n	0.30	5.0
8	66	4	29.14	29.18	22	3	Pt. cloudy	e	0.05	0.5
9	8	12	29.20	29.28	15	2	Pt. cloudy	e	0.05	0.5
10	16	21	29.44	29.49	26	10	Pt. cloudy	w	trace.	trace.
11	20	27	29.56	29.56	28	15	Pt. cloudy	n e	0.0	0.0
12	27	34	29.41	29.02	34	24	Cloudy	s e	0.70	3.0
13	37	34	28.77	28.50	40	33	Cloudy	s	0.60	0.0
14	30	30	28.78	28.85	35	29	Cloudy	w	0.05	0.50
15	27	25	28.94	28.88	32	24	Cloudy	w	trace.	trace.
16	16	22	28.93	28.89	26	16	Pt. cloudy	s	0.10	1.0
17	17	21	28.91	29.01	32	15	Pt. cloudy	w	0.0	0.0
18	13	13	29.13	29.08	32	11	Pt. cloudy	s w	0.10	1.0
19	10	11	29.05	29.16	14	6	Pt. cloudy	s w	0.02	0.25
20	14	14	29.12	29.13	15	10	Pt. cloudy	s	0.10	1.0
21	15	16	29.13	29.16	19	11	Pt. cloudy	s w	0.10	1.0
22	17	27	29.25	29.40	30	7	Pt. cloudy	w	0.0	0.0
23	24	22	29.57	29.57	32	6	Pt. cloudy	w	0.0	0.0
24	20	20	29.50	29.24	31	17	Pt. cloudy	s	0.0	0.0
25	21	27	28.70	28.98	31	17	Pt. cloudy	n e	0.30	5.0
26	24	22	28.95	28.88	31	21	Pt. cloudy	w	0.0	0.0
27	8	15	28.70	28.60	26	7	Pt. cloudy	s w	0.02	0.25
28	9	14	28.70	28.84	22	8	Pt. cloudy	w	0.0	0.0
29	-4	-2	29.00	29.20	15	-7	Pt. cloudy	w	0.0	0.0
30	6	7	29.20	29.03	12	-2	Pt. cloudy	s w	0.0	0.0
31	14	18	29.05	29.08	24	6	Cloudy	s w	0.0	0.0
Sum	626	706	902.44	901.52	937	486			2.91	19.0
Mean	20.2	22.8	29.111	29.081	30.2	15.7				

BULLETINS

OF THE

AGRICULTURAL COLLEGE EXPERIMENT STATION

ISSUED DURING THE

YEAR ENDING JUNE 30, 1910.

FERTILIZER ANALYSES.

ANDREW J. PATTEN AND C. B. COLLINGWOOD.

Bulletin No. 256.

SUMMARY OF FERTILIZER LAW.

The inspection and analyses of the commercial fertilizers offered for sale in Michigan are made under authority of an act of the Legislature, approved March 10, 1885. The full text of the law has been printed in former bulletins, and its salient points alone will be referred to here. It provides that all commercial fertilizers, retailing for more than ten dollars per ton, shall be accompanied by a statement certifying the number of net pounds in the given sack, the brand, name and address of the manufacturer, and a chemical analysis stating the percentages of nitrogen, of potash soluble in water, of available (soluble and reverted) phosphoric acid, and the insoluble phosphoric acid. (Sec. 1.) It provides that the manufacturer, importer or agent (the latter only in case the manufacturer fails to comply with the law), shall pay annually a license fee of twenty dollars for each brand offered for sale. (Sec. 3.) It provides that any person offering unguaranteed or over-guaranteed goods, shall be subject to a fine. (Sec. 6.) The full text will be furnished on application.

LICENSED BRANDS.

Twenty-three manufacturers and fertilizer companies have licensed 191 distinct brands for sale in the state during the season of 1909. These brands, appearing in the following tables of analyses, and no others can be legally sold.

Parties manufacturing or importing fertilizers for their own use and not for sale are not affected by the restrictions of the law.

COLLECTION OF SAMPLES.

The sampling agents of the Station, during the months of April, May and June, drew 346 samples from dealers' stocks representing 167 different brands. The failure to get samples of 24 brands is due to the fact that many of them are sold only in the fall, then, too, a few companies sell direct to the consumer through the Grange and other organizations and consequently it is only by chance that samples of such goods are obtained. If persons ordering goods in this way wish to have them inspected they will protect themselves and at the same time confer a favor on this department

by notifying us, and upon the arrival of the goods an inspector will be sent to draw samples.

It is the desire of this department to make the inspection as complete as possible, and any information to further this end from dealer or consumer will be greatly appreciated. In all cases of failure to find a brand on the market, the analysis was made on the manufacturer's sample as indicated in the tables of analyses.

RESULTS OF INSPECTION.

A study of the tables of analyses shows that, of the 235 samples analyzed, representing 190 brands, 74 (31%) are below guarantee* in one or more constituents. Thirty-four (14%) are below guarantee in nitrogen, 23 (9.8%) are below guarantee in available phosphoric acid, and 28 (12%) are below guarantee in potash. Six (2.6%) are below guarantee in nitrogen and potash, 3 (1.3%) in nitrogen and available phosphoric acid and 2 (0.8%) in available phosphoric acid and potash.

While there are, as stated above, 74 samples falling below guarantee in one or more constituents, there are, however, only 5 (2%) that are more than 75 cents per ton below their guaranteed commercial value. That is the shortage in one constituent is compensated by an excess of the guarantees in the other constituents. This is a very satisfactory showing.

SCHEDULE OF TRADE VALUES.

In accordance with the custom adopted and followed in previous years the following schedule of prices for determining the commercial valuation of a fertilizer is published:

Nitrogen	18c. per pound.
Potash soluble in water	5c. " "
Available phosphoric acid	5½c. " "
Total phosphoric acid in bone	4c. " "
Insoluble phosphoric acid in fertilizers containing nitrogen	2c. " "

In fertilizers containing no nitrogen no value is given to insoluble phosphoric acid. The valuation of a fertilizer is determined as follows: The percentage or pounds per hundred of each ingredient (nitrogen, available phosphoric acid, insoluble phosphoric acid and potash) is multiplied by 20, giving the number of pounds of each ingredient in a ton. These figures are then multiplied by their respective pound prices.

In the last column of the table of analyses headed "Valuation" is given the commercial valuation of the samples as guaranteed and as found based upon the prices quoted above.

*A shortage of more than 0.10 per cent of nitrogen or of more than 0.20 per cent of available phosphoric or potash is considered below guarantee.

COMMERCIAL VALUATIONS.

In calculating the valuations we have assumed that the sources of the various ingredients have been the same in all cases, which of course is not true and also unfair to the manufacturer using only high grade goods, as it places the manufacturer who uses low grade materials on the same level.

However, it should be clearly understood that a station valuation does not represent the proper retail price of the fertilizer at the point of consumption. It does represent the cash cost, at the larger fertilizer centers of the middle west, of an amount of nitrogen, available phosphoric acid and potash in unmixed, standard raw materials of good quality, corresponding with the same amount found in one ton of the fertilizer in question.

The difference between the selling price and valuation is represented by the cost of storing, grinding, bagging, hauling and freighting the goods, commissions to agents and dealers, bad debts, depreciation of machinery, interest on investment, etc. The percentage of difference between the valuation and selling price should not be more than 35 or 40.

Commercial valuations are useful to show whether a fertilizer is worth its guaranteed money value. Purchasers will often find them useful in comparing the relative values of similar brands offered by different manufacturers.

The commercial valuation bears no relation to the agricultural value of a fertilizer, this is measured only by the increased yield of crop due to its use.

The mixing of the ingredients of which a fertilizer is composed does not increase their crop-producing power, they would produce the same effect if applied separately. The mixing simply lessens the labor of applying the materials.

THE PURCHASE OF FERTILIZERS.

The use of commercial fertilizers in the State of Michigan is increasing very rapidly. In 1906 the manufacturers reported sales approximating 20,000 tons, while the sales for the present season will not be far from 40,000 tons. In 1908 there were 149 licensed brands on sale. This year there are 191 brands, an increase in only one year of 42 brands.

The quality of the fertilizers has remained about the same for a number of years although there is a tendency upon the part of some of the manufacturers to put out more of the high grade goods.

In the Fertilizer Bulletin, No. 252, of last year, we pointed out that the high-grade fertilizers furnish the plant-food at a less cost per pound than the medium or low-grade goods. While the price per ton is somewhat higher the actual cost of the plant-food in the average high-grade fertilizer is for nitrogen eight cents per pound cheaper than in the low-grade goods and for available phosphoric acid and potash two cents per pound cheaper than in the low-grade goods.

"The highest cost for nitrogen, available phosphoric acid and potash in the high-grade goods was not greater than the lowest cost for the same in the low-grade goods."

In purchasing commercial fertilizers the point to be considered above all others is the cost of the plant-food per pound. The name of the manu-

facturer, brand name, or other advertising matter should receive attention only after it has been determined which brand furnishes the required plant-food for the least amount of money.

The following rule will easily enable one to compute the cost per pound of the nitrogen, available phosphoric acid and potash in any fertilizer.

Nitrogen: Multiply the selling price per ton by 18 and divide the result by the commercial valuation.

Available phosphoric acid: Multiply the selling price per ton by $5\frac{1}{2}$ and divide the result by the commercial valuation.

Potash: Multiply the selling price per ton by 5 and divide the result by the commercial valuation.

Examples: A fertilizer contains 0.95% nitrogen, 8.80% available phosphoric acid and 1.07% potash. It sells for $19.48 per ton and the commercial valuation is $14.51.

$19.48 \times 18 = 350.64$
$350.64 \div 14.51 = 24.2$ cents, cost of nitrogen per pound.

$19.48 \times 5\frac{1}{2} = 107.14$
$107.14 \div 14.51 = 7.4$ cents, cost of available phosphoric acid per pound.

$19.48 \times 5 = 97.40$
$97.40 \div 14.51 = 6.7$ cents, cost of potash per pound.

A fertilizer contains 4.11% nitrogen, 8.12% available phosphoric acid and 7.12% potash. It sells for $39.00 per ton and the commercial valuation is $32.28.

$39 \times 18 = 702.00$
$702.00 \div 32.28 = 21.7$ cents, cost of nitrogen per pound.

$39 \times 5\frac{1}{2} = 214.50$
$214.50 \div 32.28 = 6.6$ cents, cost of available phosphoric acid per pound.

$39 \times 5 = 195.00$
$195.00 \div 32.28 = 6.0$ cents, cost of potash per pound.

While this method may be open to the objection that the schedule of prices adopted for determining the station valuations are not the true commercial prices, still, for the purpose of comparing one fertilizer with another it makes little difference whether they are true values or purely arbitrary.

There is another objection that might be raised against this method: it does not take into account the sources of the plant-food and their differences in value, but, since the agricultural value of nitrogen, phosphoric acid and potash from different sources cannot be determined with accuracy we have thought it fair for our purpose to consider the nitrogen, phosphoric acid and potash from different sources to be equal in value.

Following are the names of parties from whose stocks samples were drawn:

Adair—C. H. Lipke.

Adrian—Cutler, Dickerson & Co., W. R. Bradish, C. C. Van Doren, Chas. Eayrs, Clifford Ayers, J. E. Bennett.

Algonac—H. B. Gunniss.

Almont—Frank Bishop, Hart & Sullivan, J. Eastman.

Armada—S. I. Stump.

Azalia—A. D. Masten, Calvin Critchett.

Battle Creek—Robert Binder, J. E. Moon.

Bay City—Meagher Bros.

Benton Harbor—B. M. Nowlen & Co., C. E. & C. H. Hilton.

Blissfield—Continental Sugar Co., M. Wolverton.

Bridgman—Bridgman Supply Co., R. Widdis.

Buchanan—B. F. Morley, Wm. Speckine.

Carlton—L. J. Guermann.

Caro—M. H. Vaughan & Sons' Co., Geo. Vantine & Co.

Charlevoix—West Michigan Sugar Co.

Charlotte—L. H. Shephard Milling Co.

Clayton—E. H. Hutchins.

Coldwater—A. J. Fisk, Treat & Sons.

Coloma—J. T. Vanderveer, Wm. Stratton, Rube Hazen.

Coopersville—Lang Bros., Reynolds Bros.

Covert—J. R. Spelman & Co.

Croswell—H. E. Lovejoy, D. Quail & Son.

Crystal—Crystal Merc. Co., Ltd.

Davison—O. K. Hathaway, Frank H. Hill, Wm. E. Hill, C. S. Stambough.

Deerfield—Frank Timmins.

Disco—J. W. Switzer.

Dryden—Frank Bartlett.

Dundee—W. B. Haines.

Eaton Rapids—Crane & Crane, J. T. Hall & Son.

Elm—Wolfram Bros.

Farmington—A. Otis.

Fennville—John Sherman.

Fremont—Dirk Kolk.

Grape—Elmer Smock.

Grand Rapids—Jones Seed Co., Brown Seed Co., Eagle Hide Co.

Hamilton—John Koops.

Hartford—Edward Finley.

Hillsdale—Wm. Cole, G. A. Aldrich & Son, W. L. Kelley,

Holland—H. W. Harrington, Mulder & Lugas, Klaas Dykhuis, Geo. Speet, Groenewald & De Vries, H. H. Zwemer, John Meeswesner.

Hudson—Atherton & Garling.

Hudsonville—Fred Jonker.

Ida—S. A. Kring, N. A. Weipert.

Imlay City—Fairweather & Steele, C. S. Marshall.

Inkster—A. L. Hanchett, Fred Van Alstine.

Jackson—Isbell Seed Co., J. E. Bartlett & Co., James Boland Fert. Co.

Jonesville—L. L. Smith.

Kalamazoo—Woodham, Oakley & Oldfield Co.
Lansing—E. H. Hume, Du Bois & Hughes, The Briggs Co.
Lapeer—Cary Grain Co.
Lawton—F. S. Phelps, C. Dunham.
Lennon—Mrs. Cris Seigle.
Lenox—Ira Lovejoy, Farmers' Elevator Co., Richmond Elevator Co.
Manchester—Adam G. Houch.
Marine City—Philip Bable, Vincent Karnmeier.
Mason—Chas. Field, O. E. Driver.
Maybee—Chas. Jelsch, M. L. Blanch.
Mayville—W. J. Martyn, D. W. Stewart, John Hutchins, W. M. Gaubner.
Memphis—Day & McCall.
Milan—F. G. Hasley & Co., A. G. Forsythe & Co., T. W. Tolladay, Fred Barnes.
Monroe—Shroeder Bros.
Mt. Clemens—John N. Tucker, L. F. Wolf.
Mt. Morris—Lewis Horton & Co.
Munger—Schnettler Bros.
Muskegon—John Stegink, J. E. Marvin.
New Baltimore—W. H. Chapman.
New Buffalo—Seigmund Bros.
Niles—J. S. Tuttle.
Nunica—E. W. Hass, J. D. Pickett.
Otter Lake—R. F. Sherman.
Owosso—A. B. Cook.
Palmyra—P. P. Cook.
Petersburg—C. J. Cilley.
Pittsford—Carl & Childs.
Portland—Barden Bros.
Reading—Frank & Mead, E. Van Sickle, W. M. Cahou.
Redford—C. A. Lasher, Hugh Houk.
Rochester—Burr.
Rockford—Frank Saunders.
Rollin—L. C. Fitts.
Romeo—Bradley & Chubb, Romeo Hardware & Imp. Co.
Romulus—Ernest L. Bird, Chas. Downey.
Royal Oak—P. Backer, J. M. Lawson, E. A. Star & Son.
Saginaw—The Henry W. Carr Co., Stingel Bros.
St. Clair—Matt Stine, E. C. Recor & Son.
St. Joseph—John Wallace & Sons.
Smiths Creek—Joseph Lambert.
South Haven—Orlo Westgate, C. S. Mills, E. J. Merrifield, D. Leisering.
Strasburg—C. W. Rau.
Swartz Creek—N. Burleson.
Tecumseh—Brown & Co.
Temperance—J. W. Kinney.
Three Oaks—Warren Lumber Co., J. W. Smith.
Utica—Church & Church, H. D. Brown.
Vassar—E. H. Knight.
Vriesland—T. W. Haitsma.

Waldenburg—Louis Stine & Son.
Warren—F. A. Reddick.
Washington—John Dernberger, P. P. Andrews, Switzer, R. A. Teeter.
Wayne—J. B. Wallace, Geo. C. Walker, A. Riser, J. H. Lang.
Wyandotte—Fred Bush.
Ypsilanti—M. Dawson, Ypsilanti Produce Co.
Zeeland—Isaac Van Dyke, Henry Scholten, Haan & Hungerink, G. W. Hungerink, B. Van Raalts, R. Knap.

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	American Agricultural Chemical Co., Detroit, Mich.		
2116	Banner Dissolved Bone	Clayton	Claimed.... Found.....
1977	Fine Ground Bone	Benton Harbor	Claimed.... Found.....
2091	High Grade Bone and Potash	Fremont	Claimed.... Found.....
2152	High Grade Bone and Potash	Memphis	Claimed.... Found.....
1978	High Grade Garden and Vegetable Fertilizer	So. Haven	Claimed.... Found.....
2071	M. & I. Special Manure	Holland	Claimed.... Found.....
1979	Michigan 10% Potash Fertilizer	Washington	Claimed.... Found.....
1982	New York State Special	Hillsdale	Claimed.... Found.....
1980	Muriate of Potash	Benton Harbor	Claimed.... Found.....
1981	Nitrate of Soda	Benton Harbor	Claimed.... Found.....
2115	Bradley's Alkaline Bone and Potash	Mason	Claimed.... Found.....
1983	Bradley's B. D. Sea Fowl Guano	Covert	Claimed.... Found.....
1984	Bradley's Dissolved Bone and Potash	Hudson	Claimed.... Found.....
1985	Bradley's Niagara Phosphate	Hillsdale	Claimed... Found.....

1909, expressed in parts in one hundred.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
.....	.....	1	34	.....	$37 40
.....	37 20	0.36	36.84	.....	40 52
2.47	20	.....	.....	.....	24 89
2.48	26.76	.....	.....	.....	30 34
.....	12	.....	10	5	16 00
.....	12.10	0.48	11.62	**4.30**	17 08
.....	12	.....	10	5	16 00
.....	13.40	0.80	12.60	4.89	18 75
1.65	10	.....	8	5	18 74
1.79	10.20	0.64	9.56	5.11	22 30
2.47	10	.....	8	6	24 49
2.56	10.40	0.58	9.82	6.50	26 74
0.82	7	.....	5	10	18 45
0.81	7.56	0.70	6.86	10.74	21 47
0.82	10	.....	8	3	14 75
1.10	10.22	0.64	9.58	3.25	18 00
.....	.....	.....	.....	49	49 00
.....	.....	.....	.....	51.26	51 26
15	.....	.....	.....	.....	54 00
15.58	.....	.....	.....	.....	56 08
.....	12	.....	10	2	13 00
.....	12.88	0.96	11.92	1.98	15 09
2.06	10	.....	8	1.50	17 71
2.25	10.58	1.22	9.36	1.82	20 71
1.03	10	.....	8	2	14 51
1.05	10.08	1.12	8.96	2.27	16 37
0.82	9	.....	7	1	11 65
0.88	9.80	0.68	9.12	1.02	14 47

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	American Agricultural Chemical Co.—*Con.*		
1986	Bradley's Soluble Dissolved Bone	Covers	Claimed.... Found.....
1987	Bradley's Special Potash Fertilizer	Hillsdale	Claimed.... Found.....
1988	Crocker's Ammoniated Wheat and Corn Phosphate	Royal Oak	Claimed.... Found.....
2.34	Crocker's Dissolved Bone and Potash	Memphis	Claimed.... Found.....
1989	Crocker's General Crop Phosphate	Elm	Claimed.... Found.....
2150	Crocker's General Crop Phosphate	Lenox	Claimed.... Found.....
2151	Crocker's General Crop Phosphate	Warren	Claimed.... Found.....
1990	Crocker's New Rival Ammoniated Superphosphate	Eaton Rapids	Claimed.... Found.....
2072	Crocker's Universal Grain Grower	Zeeland	Claimed.... Found.....
1991	A I Potash Fertilizer	Washington	Claimed.... Found.....
1992	Homestead Bone Black Fertilizer	Royal Oak	Claimed.... Found.....
1993	Homestead High Grade Garden & Vegetable Fertil'r	Hartford	Claimed.... Found.....
2117	Homestead High Potash Phosphate	Clayton	Claimed.... Found.....
2073	Homestead Special Beet Fertilizer	Holland	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid..			Potash.	Valuation.
	Total.	Insoluble.	Available.		
.....	16	.....	14	.....	$15 40
.....	17.00	0.98	16.02	.....	17 62
0.82	10	.....	8	3	14 75
1.03	10.44	0.60	9.84	3.67	18 43
2.06	10	.....	8	1.50	17 71
2.76	10.88	1.00	9.88	1.67	22 88
.....	12	.....	10	2	13 00
.....	13.20	0.90	12.30	2.06	15 59
0.82	9	.....	7	1	11 65
1.11	9.96	0.84	9.12	0.87	15 20
0.82	9	.....	7	1	11 65
0.87	9.80	1.04	8.76	1.22	14 40
0.82	9	.....	7	1	11 65
0.85	9.90	0.64	9.26	0.97	14 45
1.23	11	.....	9	2	16 33
1.46	11.72	0.52	11.20	2.08	19 85
0.82	10	.....	8	2	13 75
1.17	11.04	1.32	9.72	2.10	17 52
0.82	10	.....	8	3	14 75
0.94	9.60	0.80	8.80	2.99	16 37
2.06	10	.....	8	1.50	17 71
2.20	10.72	1.42	9.30	2.03	20 75
1.65	10	.....	8	5	19 74
1.75	10.76	0.56	10.20	5.06	22 80
.....	12	.....	10	5	16 00
.....	13.04	0.76	12.28	4.67	18 18
1.65	10	.....	8	5	19 74
1.85	10.96	0.82	10.14	5.43	23 67

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	American Agricultural Chemical Co.—*Con.*		
1995	Homestead Sugar Beet Fertilizer	Royal Oak	Claimed.... Found.....
1994	Homestead 10% Potash Manure	Hartford	Claimed.... Found.....
1996	Red Line Complete Manure	Redford	Claimed.... Found.....
2135	Red Line Phosphate	Charlevoix	Claimed.... Found.....
2074	Red Line Phosphate with Potash	Holland	Claimed.... Found.....
2075	Wolverine Phosphate	Holland	Claimed.... Found.....
2123	Niagara Dissolved Bone and Potash	Adair	Claimed.... Found.....
1997	Niagara Grain and Grass Grower	Washington	Claimed.... Found.....
1998	Niagara Potato and Vegetable Fertilizer	Adrian	Claimed.... Found.....
1999	Niagara Wheat and Corn Produce	Adrian	Claimed.... Found.....
2092	Horse Shoe Acidulated Bone and Potash	Nuncia	Claimed.... Found.....
2219	Horse Shoe Acidulated Bone and Potash	Dundee	Claimed.... Found.....
2000	Horse Shoe Corn and Wheat Grower	Lansing	Claimed.... Found.....
2001	Horse Shoe Garden City Superphosphate	Benton Harbor	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.23 1.43	11 11.28	..... 0.58	9 10.70	2 1.95	$16 32 19 07
0.82 0.82	7 7.66	..... 0.56	5 7.10	10 10.36	18 45 21 34
0.82 0.90	9 9.64	..... 0.68	7 8.96	1 0.99	11 65 14 36
....	16 17.28	..... 1.12	14 16.16	....	15 40 17 77
....	12 13.12	..... 1.00	10 12.12	2 2.17	13 00 15 40
....	12 13.48	..... 1.08	10 12.40	....	11 00 13.64
....	12 12.64	..... 1.08	10 11.56	2 1.95	13 00 14 66
0.82 0.98	9 9.60	..... 0.94	7 8.66	1 1.04	11 65 14 47
2.06 2.10	10 9.76	..... 0.72	8 9.04	3 3.46	19 21 21 26
1.23 1.34	11 10.44	..... 0.26	9 10.18	2 2.13	16 32 18 25
0.82 0.97	12 12.40	..... 2.28	10 10.12	1 1.07	14 95 16 57
0.82 1.06	12 12.79	..... 2.04	10 10.75	1 1.16	14 95 17 59
1.65 1.77	10 10.12	..... 0.48	8 9.64	2 2.12	16 74 19 28
2.06 2.06	10 10.48	..... 0.62	8 9.86	1.50 1.68	17 71 20 20

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	American Agricultural Chemical Co.—*Con.*		
2002	Horse Shoe High Grade Vegetable Fertilizer.....	Adrian.....	Claimed.... Found.....
2004	Horse Shoe Potash Manure.....	Adrian.....	Claimed.... Found.....
2077	Horse Shoe Quick Acting Phosphate.....	Holland.....	Claimed.... Found.....
2003	Horse Shoe Special Onion and Vegetable Manure....	Washington.....	Claimed.... Found.....
2005	Horse Shoe Sugar Beet Fertilizer.....	Lansing.....	Claimed.... Found.....
2076	Horse Shoe 10-5 Potash Manure.....	Holland.....	Claimed.... Found.....
2093	Boar's Head Corn and Wheat Grower.....	Zeeland.....	Claimed.... Found.....
2094	Boar's Head Faultless Grain Grower.....	Zeeland.....	Claimed.... Found.....
2095	Boar's Head High Grade Vegetable Fertilizer.....	Zeeland.....	Claimed.... Found.....
2006	Boar's Head Potash Phosphate Fertilizer.....	Washington.....	Claimed.... Found.....
2007	Boar's Head Sure Growth Potash Manure.....	Washington.....	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65 1.81	10 10.80	..... 0.90	8 9.90	5 **4.76**	$19 74 22 52
0.82 0.92	10 12.80	..... 1.22	8 11.58	3 2.86	14 75 19 38
....	12 14.52	..... 1.44	10 13.08	....	11 00 14 39
0.82 0.88	7 6.76	..... 0.26	5 6.50	10 10.10	18 45 20 52
1.23 1.34	11 11.16	..... 0.28	9 10.88	2 2.04	16 32 18 93
....	12 13.96	..... 1.02	10 12.94	5 5.37	16 00 19 60
1.65 1.76	10 10.44	..... 0.78	8 9.66	2 2.21	16 74 19 49
0.82 0.95	9 9.64	..... 0.84	7 8.80	1 1.07	11 65 14 51
1.65 1.83	10 10.64	..... 0.64	8 10.00	5 5.31	19 74 23 16
....	12 12.20	..... 0.40	10 11.80	5 **4.75**	16 00 17 73
0.82 1.06	10 10.40	..... 0.38	8 10.02	3 3.53	14 75 18 51

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Armour Fertilizer Works, Chicago, Ill.		
2008	All Soluble	Redford	Claimed.... Found.....
2190	Ammoniated Bone with Potash	Manufacturers Sample..	Claimed.... Found.....
2009	Banner Brand	Benton Harbor	Claimed.... Found.....
2010	Bone, Blood and Potash	Redford	Claimed.... Found.....
2011	Bone Meal	Niles	Claimed.... Found.....
2078	Crop Grower	Zeeland	Claimed.... Found.....
2012	Fruit and Root Crop Special	Bridgman	Claimed.... Found.....
2153	Fruit and Root Crop Special	Blissfield	Claimed.... Found.....
2154	Fruit and Root Crop Special	Nunica	Claimed.... Found.....
2013	Grain Grower	Redford	Claimed.... Found.....
2014	High Grade Potato	Niles	Claimed.... Found.....
2155	High Grade Potato	Blissfield	Claimed.... Found.....
2156	High Grade Potato	Nunica	Claimed.... Found.....
2191	German Kainit	Manufacturers Sample..	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
2.88 2.87	8.50 10.12	0.50 1.94	8 8.18	4 4.00	$23 36 24 10
2.47 2.53	6.50 7.90	0.50 0.52	6 7.38	2 2.37	17 69 19 78
....	10.50 11.52	0.50 0.06	10 11.46	8 **7.52**	19 00 20 12
4.11 4.11	8.50 11.72	0.50 3.60	8 8.12	7 7.12	30 80 32 28
2.47 3.04	24 24.50	..... 11.92	..... 12.58	....	28 09 30 54
1.23 1.21	8.50 10.08	0.50 2.36	8 **7.72**	2 2.88	15 43 16 66
1.65 **1.32**	8.50 9.32	0.50 0.40	8 8.92	5 **3.88**	19 94 18 60
1.65 1.58	8.50 10.70	0.50 3.08	8 **7.62**	5 5.48	19 94 20 78
1.65 1.65	8.50 11.10	0.50 3.84	8 **7.26**	5 5.08	19 94 20 55
1.65 1.58	8.50 10.52	0.50 1.56	8 8.96	2 1.90	16 94 18 07
1.65 1.75	8.50 11.24	0.50 1.18	8 10.06	10 **8.74**	24 94 26 58
1.65 1.65	8.50 10.15	0.50 2.00	8 8.15	10 10.04	24 94 24 95
1.65 1.74	8.50 10.50	0.50 1.40	8 9.10	10 9.83	24 94 26.66
....	....	....	....	12 12.41	12 00 12 41

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Armour Fertilizer Works.—*Con.*		
2192	Muriate of Potash	Manufacturers Sample..	Claimed.... Found.....
2193	Nitrate of Soda	Manufacturers Sample..	Claimed.... Found.....
2096	Phosphate and Potash	Nunica	Claimed.... Found.....
2015	Raw Bone Meal	Redford	Claimed.... Found.....
2016	Armour's Standard	Washington	Claimed.... Found.....
2017	Star Phosphate	Benton Harbor	Claimed.... Found.....
2194	Steamed Bone Meal	Manufacturers Sample..	Claimed.... Found.....
2018	Sugar Beet Special	Washington	Claimed.... Found.....
2157	Sugar Beet Special	Blissfield	Claimed.... Found.....
2158	Sugar Beet Special	Zeeland	Claimed.... Found.....
2019	Wheat, Corn and Oat Special	Washington	Claimed.... Found.....
	Bash Fertilizer Company, Fort Wayne, Ind.		
2020	Bash's Ideal Grain Grower	Reading	Claimed.... Found.....
2021	Bash's Onion Grower	Jonesville	Claimed.... Found.....
2159	Bash's Onion Grower	Royal Oak	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
.....	.....	.....	.....	48	$48 00
.....	.....	.....	.....	48.44	48 44
15.63	.....	.....	.....	.....	56 27
15.44	.....	.....	.....	.....	55 58
.....	10.50	0.50	10	2	13 00
.....	11.16	0.44	10.72	2.24	14 03
3.70	22.00	.....	.....	.....	30 92
3.85	25.10	.....	.....	.....	33 94
0.82	8.50	0.50	8	3	14 95
0.87	10.64	1.68	8.96	3.26	16 92
.....	14.50	0.50	14.00	.....	15 40
.....	13.68	0.22	**13.46**	.....	14 81
1.65	20	.....	.....	.....	21 94
1.58	21.65	.....	.....	.....	23 01
0.82	8.50	0.50	8	4	15 95
0.99	10.68	1.06	9.62	**3.54**	18 10
0.82	8.50	0.50	8	4	15 95
0.76	10.60	1.48	9.12	**3.62**	16 98
0.82	8.50	0.50	8	4	15 95
0.92	10.10	1.44	8.66	**3.73**	17 14
0.82	7.50	0.50	7	1	11 85
0.80	10.00	2.72	7.28	1.13	13 11
1.60	9	1	8	2	16 96
1.35	11.16	1.18	9.98	2.12	18 43
1.50	9	1	8	8	22 60
1.10	9.40	0.48	8.92	7.95	21 91
1.50	9	1	8	8	22 60
0.92	9.95	0.60	9.35	8.46	22 30

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Robert Binder, Battle Creek.		
2023	Binder's Blood and Bone Fertilizer	Battle Creek	Claimed.... Found.....
2114	Binder's Blood and Bone Fertilizer	Battle Creek	Claimed.... Found.....
	James Boland Fertilizer Works, Jackson.		
2097	Blackman Brand General Crop	Ypsilanti	Claimed.... Found.....
2098	Blackman Brand Sugar Beet, Onion and Potato	Jackson	Claimed.... Found.....
	Buffalo Fertilizer Company, Buffalo, New York.		
2099	Ammoniated Bone Black	Rockford	Claimed.... Found.....
2195	Bone Meal	Manufacturers Sample..	Claimed.... Found.....
2100	Celery and Potato Special	Rockford	Claimed.... Found.....
2160	Celery and Potato Special	Jackson	Claimed.... Found.....
2024	Farmer's Choice	Coldwater	Claimed.... Found.....
2136	Garden Truck	Lennan	Claimed.... Found.....
2025	General Crop	Pittsford	Claimed.... Found.....
2222	Muriate of Potash	Manufacturers Sample..	Claimed.... Found.....
.....	Nitrate of Soda	No sample received....	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
5.25 **4.94**	13.17 13.96	..... 6.92	..... 7.04	....	$29 49 28 95
5.25 5.45	13.17 16.04	..... 4.26	..... 11.78	....	29 43 32 45
1.25 1.50	..... 14.40	..... 9.56	7 **4.84**	1.25 1.38	13 45 15 92
2.50 2.65	..... 16.32	..... 9.72	10 **6.60**	3 **2.07**	23 00 22 75
1.23 1.48	..... 12.64	..... 3.18	8 9.46	2.50 2.30	15 72 19 30
2.87 3.38	22 23.85	....	....	....	27 93 31 30
1.64 1.78	..... 11.80	..... 1.20	8 10.60	10 **8.80**	24 70 27 34
1.64 1.67	..... 10.70	..... 1.44	8 9.26	10 10.06	24 70 26 82
0.82 0.81	..... 11.24	..... 2.16	8 9.08	5 4.95	16 75 18 70
3.28 3.37	..... 12.92	..... 0.58	8 12.34	7 **5.07**	27 60 30 99
....	..... 10.80	..... 0.42	9 10.38	3 3.33	12 90 14 90
....	....	....	....	48 48.48	48 00 48 48
15	....	....	....	....	54 00 .....

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Buffalo Fertilizer Co.—*Con.*		
2101	Ohio and Michigan Special	Coopersville	Claimed.... Found.....
2102	Soluble Bone	Coopersville	Claimed.... Found.....
2026	York State Special	Coldwater	Claimed.... Found.....
2138	Gleaner Acid Phosphate	Mayville	Claimed.... Found.....
2139	Gleaner Favorite	Mayville	Claimed.... Found.....
2125	Gleaner General Grower	Marine City	Claimed.... Found.....
2126	Gleaner Phosphate and Potash	Marine City	Claimed.... Found.....
2127	Gleaner Special	Marine City	Claimed.... Found.....
	E. Burton, St. Joseph.		
2027	Meal and Bone	St. Joseph	Claimed.... Found.....
	Cincinnati Phosphate Company, Cincinnati, Ohio.		
2196	Capitol Bone & Phosphate Mixture Wheat Special	Manufacturers Sample	Claimed.... Found.....
2028	Capitol Dissolved Phosphate and Potash	Lawton	Claimed.... Found.....
2029	Capitol Grain and Grass Grower	Lawton	Claimed.... Found.....
2079	Capitol Tobacco, Potato and Beet Grower	Holland	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
0.82 1.24	..... 13.40	..... 2.02	10 11.38	1 2.28	$14 95 20 95
....	..... 16.24	..... 1.24	14 15.00	....	15 40 16 50
1.64 1.75	..... 10.88	..... 0.38	9 10.50	5 5.44	20.80 23 42
....	15 16.68	..... 0.82	14 15.86	....	15 40 17 44
1.64 1.09	9 11.80	1 1.20	8 10.60	4 5.00	19 10 21.06
0.82 1.29	11 12.20	1 2.20	10 10.00	1 2.38	15 35 18 90
....	11 10.76	1 0.56	10 10.20	2 3.45	13 00 14 67
0.82 1.10	9 12.36	1 1.38	8 10.98	4 4.27	16 15 20 82
4 4.46	15 13.50	....	....	0.36 0.27	26 76 27 12
1.65 1.82	16 21.05	6 9.84	10 11.21	1 1.42	20 34 24 23
....	11 13.48	1 1.84	10 11.64	4 3.91	15 00 16 71
0.82 0.95	9 10.88	1 0.92	8 9.96	2 2.05	14 15 16 78
0.82 0.87	9 12.16	1 1.64	8 10.52	4 3.77	16 15 19 12

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Cincinnati Phosphate Co.—*Con.*		
2161	Capitol Tobacco, Potato and Beet Grower	Mason	Claimed.... Found.....
2080	Capitol Truck and Tobacco Fertilizer	Holland	Claimed.... Found.....
2030	Capitol Wheat Grower	Lawton	Claimed.... Found.....
	Darling and Company, Chicago, Ill.		
2033	Big Potash	Washington	Claimed.... Found.....
2034	Chicago	Washington	Claimed.... Found.....
2162	Chicago	Ypsilanti	Claimed.... Found.....
2163	Chicago	Bridgman	Claimed.... Found.....
2035	Farmer's Favorite	South Haven	Claimed.... Found.....
2164	Farmer's Favorite	Ypsilanti	Claimed.... Found.....
2165	Farmer's Favorite	Lansing	Claimed.... Found.....
2036	General Crop	Coldwater	Claimed.... Found.....
2137	Phosphate and Potash	Smith's Creek	Claimed.... Found.....
2037	Pure Bone and Potash	Lansing	Claimed.... Found.....
2166	Pure Bone and Potash	Lawton	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
0.82 0.80	9 11.55	1 1.52	8 10.03	4 **3.76**	$16 15 18 27
1.64 1.67	7 8.80	1 0.92	6 7.88	6 7.26	18 90 22 29
....	13 15.60	1 3.18	12 12.42	....	13 20 13 66
1.23 1.21	10 11.68	2 2.88	8 8.80	10 11.98	24 03 27 17
1.65 1.72	10 12.40	2 3.72	8 8.68	2 2.71	17 54 19 94
1.65 1.63	10 13.15	2 4.04	8 9.11	2 2.62	17 54 20 13
1.65 1.62	10 13.80	2 5.12	8 8.68	2 2.74	17 54 20 17
2.47 **2.36**	10 14.60	2 4.12	8 10.48	4 4.94	22 49 26 62
2.47 2.43	10 14.40	2 4.68	8 9.72	4 5.64	22 49 26 94
2.47 2.43	10 15.15	2 5.04	8 10.11	4 5.94	22 49 27 81
0.82 0.96	10 11.08	2 2.10	8 8.98	6 6.64	18 15 20 80
....	..... 11.44	..... 0.42	10 11.02	2 1.97	13 00 14 09
2.14 **1.93**	20.15 24.50	....	....	6 **5.74**	29 82 32 28
2.14 **1.11**	20.15 26.88	....	....	6 **5.16**	29 82 30 65

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Darling & Co., Chicago.—*Con.*		
2038	Pure Ground Bone	Lawton	Claimed.... Found.....
2167	Pure Ground Bone	Lansing	Claimed.... Found.....
2039	Sure Winner	Washington	Claimed.... Found.....
2040	Vegetable and Lawn Fertilizer	Lansing	Claimed.... Found.....
2124	Western Brand	Mt. Clemens	Claimed.... Found.....
	Grand Rapids Glue Company, Grand Rapids, Mich.		
2081	Grand Rapids	Grand Rapids	Claimed.... Found.....
	Grange Fertilizer Company, Detroit, Mich.		
2128	All Crops Special	New Baltimore	Claimed.... Found.....
2118	Complete Manure	Monroe	Claimed.... Found.....
2119	Corn, Oats and Grass Fertilizer	Romulus	Claimed.... Found.....
2197	High Grade Concentrated Wheat Manure	Manufacturers Sample	Claimed.... Found.....
2103	Potato and Vegetable Fertilizer	Romulus	Claimed.... Found.....
2168	Potato and Vegetable Fertilizer	Romulus	Claimed.... Found.....
2120	Wheat Fertilizer No. 1	Milan	Claimed.... Found.....
2140	Wheat Fertilizer with Potash	Clio	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
2.47 **1.17**	23 30.80	....	....	....	$27 29 28 75
2.47 **2.34**	23 29.43	....	....	....	27 29 31 96
0.82 0.86	10 12.40	2 1.66	8 10.74	3 3.30	15 55 18 86
3.30 3.21	10 11.58	2 2.04	8 9.54	7 7.70	28 48 30 55
0.41 0.46	..... 7.72	..... 0.30	7 7.42	0.50 1.58	9 67 11 51
2 2.31	15 15.24	7 8.08	8 **7.16**	1 1.46	19 80 20 87
1.03 1.15	10 10.60	..... 0.58	8 10.02	2 2.09	14 50 17 48
0.82 0.86	9 10	..... 2.14	7 7.86	1 1.26	11 65 13 84
1.65 1.92	10 12.12	..... 0.40	8 11.72	2 2.07	16 74 22 03
1.23 1.17	11 11.20	..... 0.60	9 10.60	2 2.17	16 30 18 18
0.82 1.09	10 10.40	..... 0.96	8 9.44	3 **2.62**	14 75 17 30
0.82 1.01	10 10.45	..... 0.48	8 9.97	3 4.45	14 75 19 24
....	16 17.28	..... 1.02	14 16.26	....	15 40 17 88
....	12 13.00	..... 0.90	10 12.10	2 1.93	13 00 15 24

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Hirsh Stein & Company, Chicago, Ill.		
2041	Calumet Bone Black Grain Grower	Washington	Claimed.... Found.....
2042	Calumet Bone Phosphate and Potash	Coloma	Claimed.... Found.....
2043	Calumet Corn and Wheat Grower	Coloma	Claimed.... Found.....
2198	Calumet Dissolved Pure Bone Phosphate	Manufacturers Sample..	Claimed.... Found.....
2199	Calumet Fruit and Truck Grower	Manufacturers Sample..	Claimed.... Found.....
2082	Calumet Grain Grower	Strassburg	Claimed.... Found.....
2129	Calumet High Grade Bone Phosphate and Potash	Adair	Claimed.... Found.....
2044	Calumet High Grade Garden and Vegetable Grower	Owosso	Claimed.... Found.....
2113	Calumet Potato, Tobacco and Onion Grower	Deerfield	Claimed.... Found.....
2169	Calumet Potato, Tobacco and Onion Grower	Algonac	Claimed.... Found.....
2046	Calumet Special Potato, Tobacco and Onion Grower	Coloma	Claimed.... Found.....
2171	Calumet Special Potato, Tobacco and Onion Grower	Mayville	Claimed.... Found.....
2200	Calumet Pure Raw Bone Meal	Manufacturers Sample..	Claimed.... Found.....
2045	Calumet Special 10% Potash Manure	Adrian	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
2.06 2.12	9 11 32	1 1.62	8 9.70	1.50 1.73	$18 11 20 67
....	11 11.60	1 0.48	10 11.12	2 1.91	13 00 14 14
0.82 0.82	9 8.93	1 1.28	8 **7.65**	4 4.50	16 15 16 36
1 **0.76**	19 25.00	1 4.28	18 20.72	....	23 80 27 16
4.11 **3.08**	9 10.90	1 1.12	8 9.78	7 7.06	30 99 29 33
1.64 1.65	9 10.80	1 2.60	8 8.20	2 2.84	17 10 18 80
....	11 11.84	1 0.30	10 11.54	5 5.32	16 00 18 01
2.05 2.26	9 12.36	1 1.10	8 11.26	6 6.58	22 58 27 55
1.60 1.76	9 10.52	1 1.70	8 8.82	5 6.35	19 96 23 06
1.60 **1.47**	9 12.55	1 1.56	8 10.99	5 **4.70**	19 96 22 69
1.60 1.54	9 9.97	1 1.20	8 8.77	10 10.88	24 96 26 54
1.60 1.98	9 11.38	1 2.80	8 8.58	10 10.28	24 96 27 95
3.70 4.24	20 20.20	....	....	....	29 32 32 06
0.82 0.74	6 6.40	1 0.76	5 5.64	10 10.50	18 85 19 66

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Hirsh, Stein & Co., Chicago.—*Con.*		
2083	Calumet Sugar Beet and General Crop Fertilizer.....	Zeeland.....	Claimed.... Found.....
2170	Calumet Sugar Beet and General Crop Fertilizer.....	Milan.....	Claimed.... Found.....
2047	Calumet Sure Growth Fertilizer.....	Adrian.....	Claimed.... Found.....
2084	Calumet Universal Crop Grower.....	Ida.....	Claimed.... Found.....
2048	Calumet Wheat, Corn and Oat Special.....	Washington.....	Claimed.... Found.....
2201	Muriate of Potash.....	Manufacturers Sample..	Claimed.... Found.....
	The Jarecki Chemical Co., Sandusky, Ohio.		
2121	C. O. D. Phosphate.....	Rollin.....	Claimed.... Found.....
2049	Fish Phosphate and Potash, Tobacco and Potato Food	Adrian.....	Claimed.... Found.....
2172	Fish Phosphate and Potash, Tobacco and Potato Food	Davison.....	Claimed.... Found.....
2173	Fish Phosphate and Potash, Tobacco and Potato Food	Rollin.....	Claimed.... Found.....
2050	Lake Erie Guano with Phosphate and Potash.....	Reading.....	Claimed.... Found.....
2051	Number One Guano with Phosphate and Potash.....	Farmington.....	Claimed.... Found.....
2052	Special Sugar Beet Grower.....	Blissfield.....	Claimed.... Found.....
2053	Square Brand Phosphate and Potash.....	Pittsford.....	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.23 1.55	10 9.84	1 1.04	9 8.80	2 3.25	$16 72 18 92
1.23 1.40	10 9.86	1 1.70	9 **8.16**	2 2.66	16 72 17 17
.1 0.93	9 9.32	1 0.42	8 8.90	2 3.19	14 80 16 48
0.80 0.71	8 8.96	1 1.16	7 7.80	1 1.07	11 98 12 63
0.82 1.09	9 10.12	1 1.02	8 9.10	3 3.19	15 15 17 52
....	....	....	....	50 **47.04**	50 00 47 04
....	13 15.88	1 2.38	12 13.50	....	13 20 14 85
0.83 0.82	9 11.96	1 2.30	8 9.66	4 **3.76**	16 15 18 25
0.83 0.83	9 11.85	1 1.40	8 10.45	4 **3.66**	16 15 18 70
0.83 0.85	9 11.80	1 1.28	8 10.52	4 **3.45**	16 15 18 58
1.25 1.30	9 11.12	1 1.30	8 9.82	2.50 2.50	16 20 18 50
0.83 0.92	9 12.16	1 0.90	8 11.26	2 2.16	14 15 18 21
0.83 0.82	9 12.92	1 1.26	8 11.66	4 4.00	16 15 20 27
....	11 12.60	1 0.90	10 11.70	2 2.56	13 00 15 43

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	The Jarecki Chemical Co., Sandusky, O.—*Con.*		
2054	Tobacco and Truck Grower	Adrian	Claimed.... Found.....
2174	Tobacco and Truck Grower	Davison	Claimed.... Found.....
	Kalamazoo Rendering and Fertilizer Co. Kalamazoo, Mich.		
2055	Kazoo	Kalamazoo	Claimed.... Found.....
	Nitrate-Agencies Company, Chicago, Ill.		
2202	Acid Phosphate High Grade	Manufacturers Sample.	Claimed.... Found.....
2056	Muriate of Potash	Benton Harbor	Claimed.... Found.....
2203	Nitrate of Soda	Manufacturers Sample..	Claimed.... Found.....
2218	Sulfate of Potash	M. A. C.	Claimed.... Found.....
	Pioneer Fertilizer Company, Chicago, Ill.		
2216	High Grade Acid Phosphate	Crystal	Claimed.... Found.....
2141	Pioneer Chicago Bone Meal	Saginaw	Claimed.... Found.....
2206	Pioneer Bone Meal	Manufacturers Sample..	Claimed.... Found.....
2142	Pioneer General Crop Grower	Saginaw	Claimed.... Found.....
2213	Pioneer General Crop Grower	Crystal	Claimed.... Found.....
2217	Pioneer High Grade Phosphate and Potash	Crystal	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.66 **1.44**	7 10.04	1 0.76	6 9.28	6 **5.60**	$18 97 21 28
1.66 1.61	7 9.05	1 1.08	6 7.97	6 6.50	18 97 21 45
2.40 3.04	7 7.27	4 4.76	3 **2.51**	4 4.81	17 54 20 40
....	..... 19.10	..... 2.20	14 16.90	....	15 40 18 59
....	....	....	....	50 52.23	50 00 52 23
15.50 15.72	....	....	....	....	55 80 56 59
....	....	....	....	48 49.08	48 00 49 08
....	15 16.20	1 1.16	14 15.04	....	15 40 16 54
1.65 2.23	20 22.08	....	....	....	21 95 25 69
2.50 2.56	25 27.70	....	....	....	29 00 31 37
1.65 1.63	11 13.29	2 4.12	9 9.17	2 2.11	18 64 19 70
1.65 1.68	11 13.92	2 1.80	9 12.12	2 2.13	18 64 22 22
....	11 10.30	1 1.16	10 **9.14**	4 4.89	15 00 14 94

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Pioneer Fertilizer Co., Chicago.—*Con.*		
2143	Pioneer Potato and Vegetable Grower	Saginaw	Claimed.... Found.....
2215	Pioneer Potato and Vegetable Grower	Crystal	Claimed.... Found.....
2144	Pioneer Truck and Corn Grower	Saginaw	Claimed.... Found.....
2214	Pioneer Truck and Corn Grower	Crystal	Claimed.... Found.....
2207	Muriate of Potash	Manufacturers Sample..	Claimed.... Found.....
	The Pulverized Manure Company, Chicago, Ill.		
2145	Pulverized Cattle Manure	Lansing	Claimed.... Found.....
2221	Pulverized Sheep Manure	Manufacturers Sample..	Claimed.... Found.....
2146	Shredded Cattle Manure	Lansing	Claimed.... Found.....
2147	Shredded Cattle Manure	Lansing	Claimed.... Found.....
	The J. Smith Agricultural Chemical Co., Columbus, Ohio.		
2031	Chicago Fertilizer B. B. & P. Brand	Palmyra	Claimed.... Found.....
2175	Chicago Fertilizer B. B. & P. Brand	Utica	Claimed.... Found.....
2212	Chicago Fertilizer Calumet Phosphate	Manufacturers Sample..	Claimed.... Found.....
2032	Chicago Fertilizer Potash Special	Palmyra	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65 **1.44**	11 12.35	2 4.05	9 **8.30**	7 7.58	$23 64 23 49
1.65 **1.44**	11 13.00	2 4.08	9 8.92	7 7.12	23 64 23 71
0.82 0.83	10 11.44	1 2.02	9 9.42	4 4.31	17 25 18 45
0.82 0.93	10 11.48	1 2.06	9 9.42	4 5.31	17 25 19 81
....	....	....	....	45 46.33	45 00 46 33
2.10 **1.66**	1.20 1.00	..... 0.12	1.00 0.88	1.35 1.28	10 01 8 26
2.10 2.35	1.20 1.45	..... 0.08	1.00 1.37	1.35 1.80	10 01 11 79
2.10 **1.93**	1.20 1.05	..... 0.16	1.00 0.89	1.35 1.42	10 01 9 39
2.10 2.05	1.20 1.00	..... 0.14	1.00 0.86	1.35 1.34	10 01 9 72
1.23 **0.93**	9 10.00	1 1.56	8 8.44	2 2.22	15 62 15 44
1.23 **0.98**	9 9.80	1 1.32	8 8.48	2 1.91	15 62 15 27
....	11 13.00	1 2.24	10 10.76	2 3.07	13 00 14 90
0.82 0.80	9 10.80	1 1.50	8 9.30	4 4.52	16 15 18 23

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	The Smith Agricultural Chemical Co., Columbus, Ohio.—*Con.*		
2122	Chicago Fertilizer Western Phosphate and Potash....	Carlton.....	Claimed.... Found.....
2085	Ohio Farmers' Ammoniated Phosphate and Potash..	Hamilton.....	Claimed.... Found.....
2176	Ohio Farmers' Ammoniated Phosphate and Potash..	Maybee.....	Claimed.... Found.....
2177	Ohio Farmers' Ammoniated Phosphate and Potash..	Azalia.....	Claimed.... Found.....
2178	Ohio Farmers' Ammoniated Phosphate and Potash..	Almont.....	Claimed.... Found.....
2086	Ohio Farmers' Corn, Oat and Wheat Fertilizer.....	Hamilton.....	Claimed.... Found.....
2179	Ohio Farmers' Corn, Oats and Wheat Fertilizer.....	Milan.....	Claimed.... Found.....
2104	Ohio Farmers' Soluble Phosphate and Potash.....	Maybee.....	Claimed.... Found.....
2087	Ohio Farmers' Wheat Maker and Seeding Down.....	Hamilton.....	Claimed.... Found.....
	Speidel & Swartz, Grand Haven, Mich.		
2105	Celery Hustler.....	Grand Haven.....	Claimed.... Found.....
	Stingel Bros., Saginaw, Mich.		
2148	Sugar Beet Grower.....	Saginaw.....	Claimed.... Found.....
	Swift and Company, Chicago, Ill.		
2130	Swifts Bee Hive Fertilizer.....	Armada.....	Claimed.... Found.....
2088	Swifts Complete Fertilizer.....	Zeeland.....	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
0.82 0.72	9 10.08	1 1.04	8 9.04	2 2.06	$14 15 15 01
0.82 0.76	9 10.12	1 1.06	8 9.06	4 5.62	16 15 18 74
0.82 **0.70**	9 10.30	1 1.08	8 9.22	4 3.98	16 15 17 18
0.82 **0.67**	9 10.65	1 1.60	8 9.05	4 5.98	16 15 18 99
0.82 **0.68**	9 11.50	1 2.48	8 9.02	4 5.25	16 15 18 61
1.23 **1.12**	9 10.28	1 1.08	8 9.20	2 2.06	15 63 16 64
1.23 **0.91**	9 9.75	1 1.72	8 8.03	2 1.92	15 63 14 72
....	11 12.52	1 1.14	10 11.38	2 2.10	13 00 14 62
0.82 **0.71**	9 10.32	1 1.32	8 9.00	2 1.85	14 15 14 84
6 6.28	3.76 4.55	0.69 1.10	3.17 3.45	1.25 1.32	26 62 28 16
3 3.94	20 19.55	13 12.88	7 **6.67**	6 **5.55**	29 70 32 23
0.82 0.83	9 10.40	1 0.88	8 9.52	3 3.18	15 15 17 00
1 1.02	9 11.36	1 3.20	8 8.16	1 1.23	13 80 15 16

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Swift & Co., Chicago.—*Con.*		
2107	Swifts Garden City Phosphate	Wayne	Claimed.... Found.....
2108	Swifts Ground Steamed Bone	Muskegon	Claimed.... Found.....
2182	Swifts Onion, Potato and Tobacco Fertilizer	Rochester	Claimed.... Found.....
2183	Swifts Onion, Potato and Tobacco Fertilizer	Eaton Rapids	Claimed.... Found.....
2208	Swifts Pulverized Sheep Manure	Manufacturers Sample..	Claimed.... Found.....
2058	Swifts Pure Bone Meal	South Haven	Claimed.... Found.....
2106	Swifts Pure Dissolved Bone and Potash	Muskegon	Claimed.... Found.....
2059	Swifts Pure Lawn Fertilizer	Holland	Claimed.... Found.....
2109	Swifts Pure Lawn Fertilizer	Grand Rapids	Claimed.... Found.....
2090	Swifts Special Phosphate and Potash	Zeeland	Claimed.... Found.....
2180	Swifts Special Phosphate and Potash	St. Clair	Claimed.... Found.....
2181	Swifts Special Phosphate and Potash	Wayne	Claimed.... Found.....
2061	Swifts Sugar Beet Grower	Adrian	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
.....	15	1	14	.....	$15 40
.....	16.90	1.10	15.80	.....	17 38
1.65	20	.....	.....	.....	21 94
1.81	23.50	.....	.....	.....	25 32
1.65	10	2	8	7	22 54
1.61	11.30	3.72	**7.58**	7.08	23 40
1.65	10	2	8	7	22 54
1.72	12.20	4.34	7.86	7.06	23 60
2.50	2	.....	.....	2	11 80
2.43	1.85	.....	.....	**1.50**	10 99
2.50	25	.....	.....	.....	29 00
2.76	25.40	.....	.....	.....	30 26
0.57	20.00	2.00	18.00	4.00	26 65
1.44	20.10	3.95	**16.15**	4.23	28 78
3.75	23	.....	.....	.....	31 90
3.99	24.45	.....	.....	.....	33 92
3.75	23	.....	.....	.....	31 90
4.05	24.20	.....	.....	.....	33 94
.....	11	1	10	2	13 00
.....	12.56	0.38	12.18	**1.69**	15 09
.....	11	1	10	2	13 00
.....	13.10	1.28	11.82	2.09	15 09
.....	11	1	10	2	13 00
.....	12.35	1.12	11.23	2.25	14 60
2.50	10	2	8	5	23 60
2.82	11.62	4.24	**7.38**	5.31	25 28

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Swift & Co., Chicago.—*Con.*		
2184	Swifts Sugar Beet Grower	Zeeland	Claimed.... Found.....
2062	Swifts Superphosphate	Charlotte	Claimed.... Found.....
2185	Swifts Superphosphate	Three Oaks	Claimed.... Found.....
2186	Swifts Superphosphate	Rochester	Claimed.... Found.....
2187	Swifts Superphosphate	Eaton Rapids	Claimed.... Found.....
2063	Swifts Truck Grower	Rochester	Claimed.... Found.....
2064	Swifts Vegetable Grower	South Haven	Claimed.... Found.....
2057	Muriate of Potash	Holland	Claimed.... Found.....
	Tuscarora Fertilizer Company, Chicago, Ill.		
2209	Acid Phosphate	Manufacturers Sample	Claimed.... Found.....
2110	Ammoniated Phosphate	Zeeland	Claimed.... Found.....
2066	Bone and Potash	Coloma	Claimed.... Found.....
2111	Michigan Special	Zeeland	Claimed.... Found.....
2188	Michigan Special	Munger	Claimed.... Found.....
2189	Michigan Special	Otter Lake	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
2.50 2.80	10 12.45	2 4.20	8 8.25	5 6.55	$23 60 27 39
1.65 1.64	10 12.96	2 5.18	8 **7.78**	2 2.84	17 54 18 82
1.65 1.70	10 13.25	2 6.00	8 **7.25**	2 1.98	17 54 18 48
1.65 1.61	10 13.80	2 6.20	8 **7.60**	2 2.01	17 54 18 65
1.65 1.55	10 12.85	2 6.00	8 **6.85**	2 1.98	17 54 17 50
0.82 0.89	9 10.80	1 2.72	8 8.08	4 4.68	16 15 17 86
3.29 **3.07**	11 11.92	2 2.61	9 9.31	10 14.00	32 54 36 33
....	....	....	....	45 51.01	45 00 51 01
....	14.50 15.90	0.50 0.32	14 15.58	....	15 40 17 14
0.82 0.84	7.50 9.82	0.50 2.74	7 7.08	1 1.69	11 85 13 60
....	10.50 12.00	0.50 0.24	10 11.76	2 2.66	13 00 15 60
1.65 1.58	8.50 11.39	0.50 4.04	8 **7.35**	5 5.80	19 94 21 20
1.65 **1.54**	8.50 11.60	0.50 2.36	8 9.24	5 5.05	19 94 21 69
1.65 **1.29**	8.50 10.50	0.50 0.92	8 9.58	5 **4.46**	19 94 20 01

Results of analyses of commercial fertilizers for

Laboratory number.	Trade Name.	Locality where sample was taken.	
	Tuscora Fertilizer Co., Chicago.—*Con.*		
2210	Steamed Bone Meal	Manufacturers Sample..	Claimed.... Found.....
2267	Tuscarora Bone Phosphate	New Buffalo	Claimed.... Found.....
2068	Tuscarora Fruit and Potato	New Buffalo	Claimed.... Found.....
2149	Tuscaro Garden	Munger	Claimed.... Found.....
2112	Tuscarora Standard	Zeeland	Clamied.... Found.....
2211	Tuscarora Trucker	Manufacturers Sample..	Claimed.... Found.....
2069	Wolverine Special	Reading	Claimed.... Found.....
	Wuichet Fertilizer Company, Dayton, Ohio.		
2070	Onion and Truck Fertilizer	Manchester	Claimed.... Found.....

1909, expressed in parts in one hundred.—Con.

Nitrogen.	Phosphoric Acid.			Potash.	Valuation.
	Total.	Insoluble.	Available.		
1.65 **1.53**	20 21.25	....	....	....	$21 94 22 51
....	10.50 11.96	0.50 0.30	10 11.66	....	11 00 12 83
1.65 **1.38**	8.50 10.40	0.50 2.02	8 8.38	10 10.51	24 94 25 62
2.83 **2.72**	8.50 11.04	0.50 3.72	8 **7.32**	4 4.93	23 19 24 26
1.65 1.57	8.50 11.00	0.50 2.80	8 8.20	2 2.06	16 94 17 85
4.11 **3.49**	8.50 10.10	0.50 2.72	8 **7.38**	7 8.28	30 80 30 05
0.82 0.74	8.50 10.84	0.50 1.30	8 9.54	4 4.15	15 95 17 82
1.50 1.59	9 13.48	1 4.10	8 9.38	8 8.98	22 60 26 66

REARING CALVES ON SKIM-MILK AND SUPPLEMENTARY FEED.

Bulletin No. 257.

INTRODUCTION.

Michigan conditions are demanding the application of economic methods in beef production. Though feeders may be produced from cows with calves at the side on large areas of cheap grazing land, it is doubtful whether this method can be successfully employed on the average Michigan farm operated under an intensive system. In this case, more revenue must be secured from a cow during the year than that produced in the feeder steer or heifer receiving the entire product of the mother rearing it. It is true that pedigreed animals, especially of the beef classes, reared for sale for breeding or for show purposes, can be profitably suckled by their dams because of the higher price they bring. The rearing of cheap feeders by the pail method has become an important question in Michigan with the beef producers.

Dairymen, of necessity, have long practiced rearing calves on skim-milk supplemented by grain, hay, silage, etc., and some have even dispensed with skim-milk feeding in quite a large measure.

Because of conditions enumerated, it has been deemed advisable to publish the records of sixty-three pail-fed calves giving complete data from birth date to one year of age. These records have accumulated during the past three or four years and include both beef and dairy types.

As a general thing the pail-fed calf suffers from neglect and want of sufficient feed of the proper character. There is no secret to success in rearing calves on skim-milk and supplementary feed combined with judicious management. The following records are presented to give the stockman some definite and complete data on the subject relative to the amount of feed required from birth to one year, possible gains and cost of production, etc. As regards cost of production, attention is directed to the fact that the average range of feed prices used for these years is much higher than those used in reports issued elsewhere during years when prices were at a much lower level. In the second place, the cost of production is increased somewhat by experimental factors which would not have to be considered under actual farm conditions. Third, while these reports cease at the feeder age, most of the young animals, except dairy heifers, were in a marketable condition and within a range of moderate profit had they been actually placed on the market. Fourth, at the prices charged there is a profit in the feed used over and above its cost of production.

It is intended to continue the work along this line in the future. Data is being procured from fall-dropped calves which are to be put

on pasture the following spring to compare results and cost with the continuous housing method hereafter reported.

The work of securing these records was instituted by R. S. Shaw, later assisted by H. W. Norton, Jr. and A. C. Anderson. The records were largely compiled and prepared for publication by Mr. Norton.

YEARLY RECORDS OF CALVES REARED ON SKIM-MILK AND SUPPLEMENTARY FEED.

H. W. NORTON, JR.

During the past four years records have been kept of a number of calves in the college herds, reared on skim-milk and supplementary feed, and sixty-three of these records are reported herein. They include both grade and pure-bred calves from the experimental and breeding herds, and are complete records of all feed consumed with weights and gains to one year of age.

The reports are presented in groups representing from six to eleven head each, as they were fed, and all calves in the same lot were fed and handled practically alike. In one lot of grades fed during 1904 and 1905, the whole milk feeding was continued from twelve to thirteen weeks, and in some cases the skim-milk feeding was continued until the calves were a year old, because of a large supply on hand with no other means of utilizing it. Considerable variation may also be noticed in the silage, roots and green feed, fed to the different lots, but this was due largely to the supply available.

The tables following give the total amounts of the several kinds of feed consumed by each calf during the year and the cost. The year is divided into four equal periods of thirteen weeks, or three months each, and the gains in weight, cost of feed and cost per cwt. gain are shown for each of the four periods from birth to three months, three to six months, six to nine months, and nine months to one year of age. The tables also show the birth weight and cost of production per cwt. at one year old for each calf. Averages are given for each lot as the feeding varied considerably in the different lots, and finally general averages are given for the entire number of sixty-three calves.

All calves reported were stable fed throughout the year, being turned out only in small exercising yards as no pasture was available, hence the cost may be considerably higher than under farm conditions where they might have been turned out to pasture during summer, saving considerable time and labor, as well as feed. This factor must be considered in studying the methods of feeding and handling employed and in comparing the costs with those reported in other bulletins. Note that some of the prices charged for feed are from 30 to 50 per cent higher than those embodied in reports of several western institutions a few years ago.

SCALE OF PRICES FOR FEED.

Whole milk	$1 00 per cwt.
Skim milk	20 per cwt.
Silage	2 50 per ton.
Hay	5 00 per ton.
Green feed	2 00 per ton.
Roots	2 00 per ton.
Dried beet pulp	15 00 per ton.
Corn meal	20 00 per ton.
Oats	20 00 per ton.
Wheat bran	18 00 per ton.
Oil cake	28 00 per ton.

CALVES NUMBERS 1 TO 30.

Calves Nos. 1 to 30 were from the Experimental Grade Beef Herd, a group of Shorthorn grade cows weighing from 800 to 1,200 pounds, which could be classed as common or average grade cows in Michigan. This herd has been kept for the purpose of determining the relative profit on a herd where the calves are suckled by their dams as compared with a herd where the cows are milked and the calves raised on skim-milk. The thirty calves reported in Lots I, II and III are the three skim-milk fed lots raised during the years 1905-1906, 1906-1907, 1907-1908. The report for the three years experiments will be published complete directly following this bulletin.

These calves were weaned at from one to three days of age and fed whole milk from the pail until five to six weeks old, then changed to skim-milk, the change being gradual, covering a period of one week. They were taught to eat grain and hay at from two to four weeks of age. The hay was alfalfa or clover, mostly the latter, and the grain mixture consisted of 3 parts corn meal, 3 parts ground oats, 1 part bran, 1 part oil cake, by weight. The grain was fed in the manger as soon as they finished drinking their milk, and while the calves were still kept in the stanchions. Silage, roots, beet pulp and green feed were also used to some extent. The beet pulp was fed, moistened with water, to furnish a succulent feed when no other was available.

LOT I.

Lot I consists of calves 1 to 10, the skim-milk fed lot of the Grade Beef Herd raised during 1905 and 1906. These calves were sired by Shorthorn bulls and were fed as previously described. The feeding was liberal with a view toward marketing as baby beef at 18 months of age, at approximately 1,000 pounds weight. Illustration 1 shows these calves at 18 months of age. In May, 1907, they sold in the yards at 5 cents per pound.

TABLE 1.

Feed consumed by Lot I to 1 year of age. No pasture.

No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Green feed, lbs.	Beet pulp, lbs.	Grain, lbs.	Cost.
1	577	2,964	547	1,056	226	71	130	962	$26 32
2	327	3,130	779	1,159	226	188	293	1,219	28 66
3	456	2,890	1,756	1,274	221	272	141	1,255	30 02
4	294	3,065	1,253	1,242	226	185	229	1,299	29 32
5	384	2,876	1,184	1,194	226	272	141	1,119	27 22
6	450	2,964	232	1,014	226	162	306	1,000	26 33
7	345	3,191	945	1,162	226	272	194	1,098	27 25
8	483	2,963	528	1,044	226	272	211	949	25 98
9	339	3,114	1,553	1,201	215	272	141	1,193	28 45
10	504	2,956	292	1,027	226	188	306	1,033	27 32
Average	416	3,011	907	1,137	224	215	209	1,113	27 69

In Table I considerable variation is shown in the amounts of silage and beet pulp Nos. 2, 6 and 10 consumed, the amounts being 293, 306 and 306 pounds respectively of beet pulp, while Nos. 6 and 10 were fed small amounts of silage, 232 and 292 lbs., as compared with 907 lbs., the average for the lot.

An explanation may be found in the fact that these three calves were exhibited on the Michigan fair circuit for six weeks during the fall of 1906, and moistened beet pulp was used during that time to take the place of silage. The table shows that the average amount of feed consumed per calf was 416 pounds whole milk, 3,011 pounds skim-milk, 907 pounds silage, 1,137 pounds hay, 224 pounds roots, 215 pounds green feed, 209 pounds beet pulp and 1,113 pounds grain, up to one year of age. The average cost of feed was $27.69 for the year.

TABLE 2.

Weights and gains of Lot I.

No.	Birth weight. lbs.	Gains.				Weight at one year. lbs.
		1st period. lbs.	2d period. lbs.	3d period. lbs.	4th period. lbs.	
1	76	129	149	107	128	589
2	78	133	173	134	148	666
3	90	135	180	137	169	711
4	81	155	202	136	162	736
5	70	128	163	109	108	578
6	72	142	146	129	122	611
7	81	142	169	138	160	690
8	66	140	140	118	120	584
9	86	140	167	131	166	690
10	64	136	151	124	109	584
Average	76.4	138.0	164.0	126.3	139.2	643.9

(Periods cover thirteen weeks or three months in all cases.)

ILLUSTRATION NO. 1.

ILLUSTRATION NO. 2.

Table 2 gives the weights at birth and one year of age, and the gains by periods of three months each. The average weight was 76 pounds at birth and 643.9 pounds at one year, an average gain of 1.55 pounds per day. The greatest gain, 164 pounds, is shown in the second three months period, a gain of 1.8 pounds per head daily during that time.

TABLE 3.

Cost by periods and cost by gains of Lot I.

No.	Cost of feed by periods.					Cost per cwt. gain.				Cost per cwt. at 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
1	$8 30	$6 01	$5 35	$6 66	$26 32	$6 43	$4 03	$5 00	$5 20	$4 46
2	6 28	6 22	6 83	9 33	28 66	4 72	3 59	5 09	6 30	4 30
3	7 43	6 81	7 14	8 64	30 02	5 50	3 78	5 21	5 11	4 22
4	6 56	6 61	7 74	8 41	29 32	4 23	3 27	5 69	5 19	3 98
5	6 65	6 42	6 02	8 11	27 22	5 19	3 94	5 52	7 50	4 70
6	6 60	5 94	5 26	8 53	26 33	4 64	4 06	4 07	6 99	4 31
7	6 82	6 33	6 77	7 33	27 25	4 80	3 74	4 90	4 58	3 95
8	7 35	6 00	5 35	7 28	25 98	5 25	4 28	4 53	6 06	4 44
9	6 44	6 87	6 96	8 18	28 45	4 60	4 11	5 31	4 92	4 12
10	7 12	5 94	5 25	9 01	27 32	5 23	3 93	4 23	8 26	4 67
Average	$6 96	$6 32	$6 27	$8 15	$27 69	$5 06	$3 87	$4 96	$6 01	$4 32

The above table shows that the average cost of feed for the year was $27.69 per head and the cost of production $4.32 per cwt. The cost of feed was greatest during the last period, as during that time considerable grain was fed. A large part of the cost during the first period of three months may be attributed to whole milk fed during the first five or six weeks. The period of cheapest production was from three to six months, as the cost of feed was low and the rate of gain was high during that time.

LOT II.

Lot II consists of calves 11 to 20, the skim-milk fed lot of the Grade Beef Herd raised during 1906 and 1907. They were out of the same cows as Nos. 1 to 10 but were sired by the pure-bred Hereford Bull, Kington 2nd, No. 134454. They were fed in much the same manner as Lot I, to be finished and marketed as baby beef at eighteen months of age. Lot II received the same grain mixture as Lot I, but no roots or green feed were used.

Illustration 2 shows Lot II at eighteen months of age just before being shipped. They were sold for 5¾ cents per pound in our own yards during May, 1908.

TABLE 4.

Feed consumed to one year of age by Lot II. No pasture.

No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Beet pulp, lbs.	Grain, lbs.	Cost.
11	379	4,130	405	1,002	142	993	$26 47
12	354	4,549	405	940	142	977	26 67
13	371	4,531	453	964	142	1,000	27 22
14	338	2,769	1,048	1,186	142	1,237	26 79
15	398	4,448	681	1,066	142	1,099	28 75
16	407	3,249	307	949	142	976	24 54
17	586	4,712	213	900	142	893	28 17
18	357	4,684	362	981	142	969	26 97
19	408	4,712	308	948	142	939	27 08
20	383	3,470	405	973	142	988	25 05
Average	398	4,125	459	991	142	1,007	$26 78

Table 4 shows that the average cost of feed for Nos. 11 to 20 up to one year was $26.78, somewhat cheaper than for Lot I during the previous year. A comparison of the two feed tables, Tables 1 and 4, shows that Lot II received less grain, hay, silage and whole milk than Lot I, and no roots or green feed were used, skim-milk being the only item in which they were fed heavier.

The greatest variation in amount of feed consumed, as shown in Table 4, is in silage. No. 14 received 1,048 pounds silage while the average for the lot was only 459 pounds. Silage feeding in the fall of 1907 was started with all the calves about Oct. 15th, and as most of them were October or November dropped calves of the previous year the twelve months was soon finished. No. 14 was born Dec. 30th, 1906, and was fed silage from October 15th to the end of the year making two and one-half months of silage feeding, which accounts for the much larger amount shown in the feed table. No. 15, fed 681 pounds, was born Dec. 6th, and was fed silage seven weeks, a longer period than any other except No. 14.

TABLE 5.

Weights and gains, Lot II.

No.	Birth weight, lbs.	Gains.				Weight at one year, lbs.
		Period 1, lbs.	Period 2, lbs.	Period 3, lbs.	Period 4, lbs.	
11	88	133	150	151	153	675
12	71	111	146	141	139	608
13	69	102	142	144	137	594
14	82	145	159	141	149	576
15	76	154	161	201	63	655
16	84	137	129	107	147	604
17	82	139	124	159	189	699
18	87	128	145	180	140	680
19	83	140	124	166	127	640
20	74	120	128	92	149	563
Average	80	131	141	148	139	629

Comparing the above table with the corresponding table for Lot I we find that Nos. 11 to 20 averaged slightly heavier at birth, but were 15 pounds lighter at one year of age. The gains during the four periods are quite uniform, ranging from 131 to 148 pounds, and the average gain per head daily from birth to one year was 1.5 pounds.

ILLUSTRATION NO. 3.

TABLE 6.

Cost of feed and gain, Lot II.

No.	Cost of feed by periods.					Cost per cwt. gain				Cost per cwt at 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
11	$6 39	$6 09	$7 29	$6 70	$26 47	$4 80	$4 06	$4 82	$4 37	$3 92
12	5 83	5 90	7 71	7 23	26 67	5 25	4 04	5 46	5 20	4 39
13	6 01	5 90	7 71	7 60	27 22	5 89	4 15	5 35	5 54	4 58
14	6 69	6 87	5 22	8 01	26 79	4 61	4 32	3 70	5 37	3 96
15	7 18	6 47	7 84	7 26	28 75	4 66	4 01	3 90	11 52	4 39
16	6 51	5 91	5 79	6 33	24 54	4 75	4 58	5 41	4 30	4 06
17	7 57	5 55	7 39	7 66	28 17	5 44	4 47	4 64	4 05	4 03
18	5 96	5 90	7 59	7 52	26 97	4 65	4 06	4 21	5 37	3 96
19	6 52	5 90	7 59	7 07	27 08	4 65	4 75	4 57	5 56	4 23
20	6 29	6 00	6 06	6 70	25 05	5 24	4 68	6 58	4 49	4 45
Average	$6 50	$6 05	$7 02	$7 21	$26 78	$4 99	$4 31	$4 86	$5 58	$4 20

The average cost of feed per head for the year was $26.78 for Lot II, as compared to $27.69 for Lot I, and the average cost per cwt. was $4.20 for Lot II, 12 cents less than the cost of Lot I. The cheapest gain, as in the first lot, come in period two, from three to six months of

age, when gain was made for $4.31 per cwt., and the most expensive gain was made in period four, when grain feeding was heavier.

LOT III.

Lot III consists of ten calves, Nos. 21 to 30, raised during 1907 and 1908 from the same dams as Lots I and II, but sired by the pure-bred Aberdeen Angus bull, Woodcote Valiant Knight 3rd, No. 80523. Like the two lots reported in the preceding pages they were included in the experiment in baby beef production, and were fed liberally to be marketed in finished condition at eighteen months of age. They are shown in Illustration 3. This lot was sold in our yards for $6.15 per cwt. for shipment to Buffalo, May, 1909.

TABLE 7.

Feed consumed to one year of age by Lot III. No pasture.

No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Beet pulp, lbs.	Grain, lbs.	Cost.
21	328	4,749	569	1,228	231	15	1,536	$32 84
22	395	4,055	591	1,142	156	15	1,473	31 21
23	345	3,246	1,420	1,291	62	0	1,686	32 50
24	479	3,707	864	1,241	177	15	1,762	34 95
25	440	4,117	314	967	159	15	1,096	27 08
26	419	4,304	607	1,127	155	15	1,491	32 10
27	503	4,056	956	1,231	99	0	1,780	35 98
28	419	5,044	393	979	177	15	1,260	30 58
29	520	4,219	799	1,199	89	15	1,474	33 13
30	592	3,689	717	1,208	177	15	1,675	34 89
Average	444	4,119	723	1,161	148	12	1,523	$32 53

The average cost of feed consumed by each of the ten calves in Lot III up to one year of age was $32.53, much higher than Lots I and II, which averaged $27.69 and $26.78, respectively, a difference of $4.84 and $5.75 per head in favor of the earlier lots in economy of production. A comparison of the feed tables for the three lots shows that Lot III received somewhat larger amounts of whole milk and skim-milk, and a much larger amount of grain, an average of 410 pounds more per head than Lot I, and 516 pounds more per head than Lot II. These are the most expensive items and readily account for the increased cost. Skim-milk feeding was continued with all the calves until about August 1, as it was available and would otherwise have been a waste product.

The amount of silage consumed varied considerably, No. 23 receiving 1420 pounds, while the average was only 723. This is accounted for by the fact that silage feeding was started early in October, and as No. 23 was a spring calf, born in March, it was fed silage several months while the others received it during a much shorter period.

TABLE 8.

Weights and gains. Lot III.

No.	Birth weight, lbs.	Gain.				Weight at one year, lbs.
		Period 1, lbs.	Period 2, lbs.	Period 3, lbs.	Period 4, lbs.	
21	73	141	167	154	141	676
22	81	143	161	153	202	740
23	85	135	187	190	149	746
24	68	167	210	169	176	790
25	70	114	130	128	193	635
26	68	116	169	112	161	626
27	82	143	185	176	128	714
28	60	146	134	169	111	620
29	77	113	143	173	87	593
30	59	145	189	223	62	678
Average	72	136	168	165	141	682

Lot III shows an average weight of 72 pounds at birth, and 682 pounds at one year, a gain of 610 pounds, or an average daily gain of 1.67 pounds per head throughout the year. The greatest gain was 168 pounds made during the second period, a daily gain of 1.84 pounds per head for the three months.

TABLE 9.

Cost of feed and cost of gain by periods, Lot III.

No.	Cost of feed by periods.					Cost per cwt. gain.				Cost per cwt. at 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
21	$6 15	$7 57	$10 81	$8 31	$32 84	$4 36	$4 53	$7 02	$5 89	$4 85
22	6 76	6 59	9 41	8 45	31 21	4 72	4 09	6 15	4 18	4 22
23	6 94	8 86	7 08	9 62	32 50	5 14	4 73	3 72	6 45	4 35
24	7 60	9 05	9 29	9 01	34 95	4 55	4 30	5 49	5 11	4 42
25	7 13	5 53	5 82	8 60	27 08	6 25	4 25	4 54	4 45	4 26
26	7 36	6 48	9 33	8 93	32 10	6 34	3 83	8 33	5 54	5 12
27	7 96	9 18	9 56	9 28	35 98	5 56	4 96	5 43	7 25	5 03
28	6 22	6 00	9 29	9 07	30 58	4 26	4 47	5 49	8 17	4 93
29	7 69	6 89	10 55	8 00	33 13	6 80	4 81	6 09	9 19	5 58
30	8 13	8 24	9 65	8 87	34 89	5 60	4 36	4 32	14 30	5 14
Average	$7 19	$7 44	$9 08	$8 81	$32 53	$5 36	$4 43	$5 66	$7 05	$4 79

The average cost per head at one year as shown in Table 9 is $32.53 or $4.79 per hundred pounds, showing that while the ten calves in Lot III averaged considerably heavier than the other two lots at the same age, 38 pounds more than Lot I and 53 pounds more than Lot II, still the additional cost of feed more than made up for the increased gain, and the average cost of production was about fifty cents greater per cwt. than for either Lot I or Lot II. In case of Lot III, as with the others, the cheapest gain was made during the stcond period.

From a comparison of these three lots it would seem that the best results could be secured by such feeding as was followed with Lots I and II, as Lot III was fed heavier throughout the year and while greater weights were attained the cost was more than proportionately increased.

LOT IV.

Lot IV consisted of eleven calves from the Grade Dairy Herd, a herd of twenty grade cows used in experimental work in up-grading by the

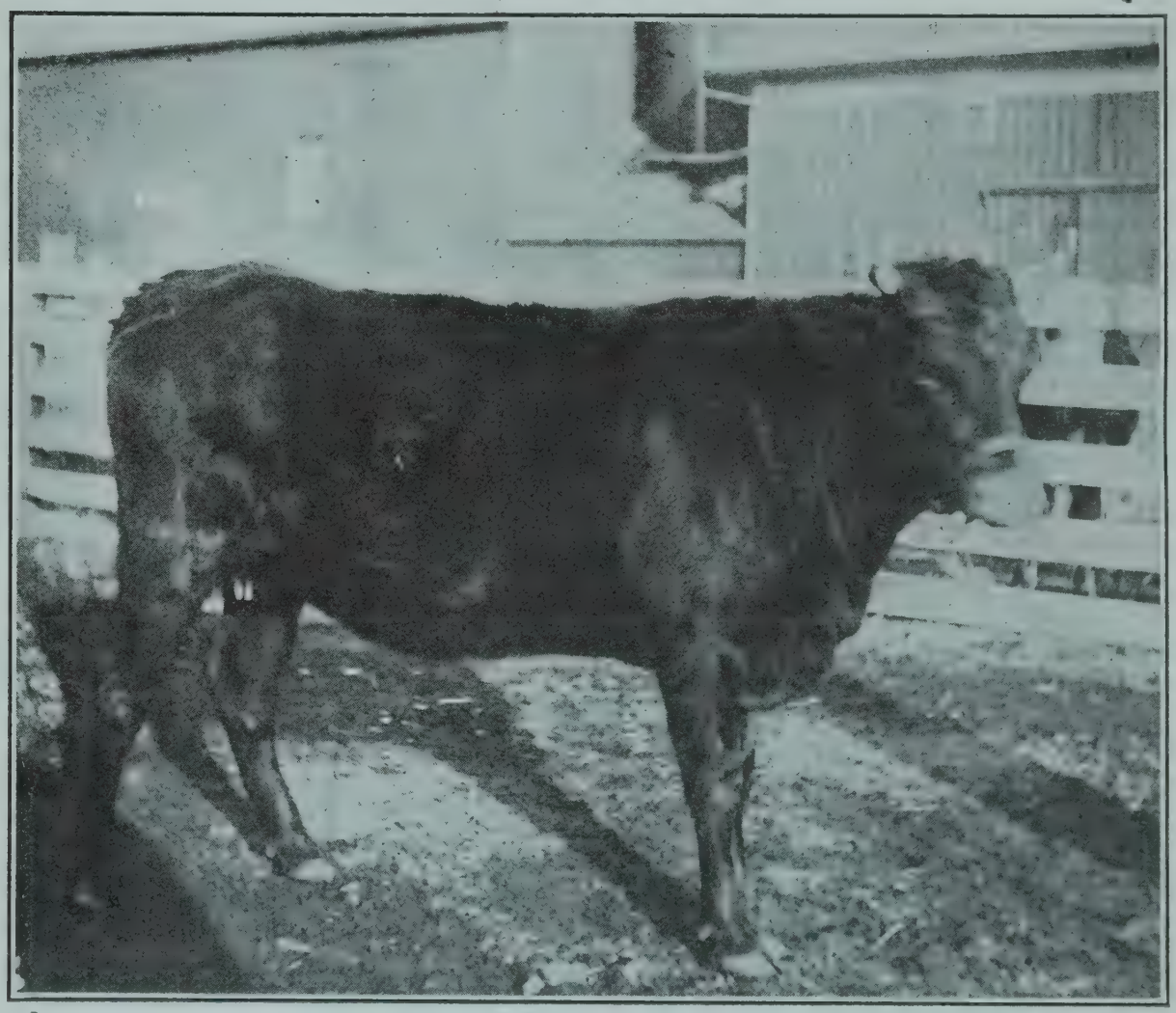


ILLUSTRATION NO. 4.

use of pure-bred sires of four breeds; viz.: Shorthorn, Holstein, Guernsey and Jersey. Of the eleven calves two were sired by a Shorthorn, one by a Holstein, three by a Jersey and five by a Guernsey bull. Illustrations 4 and 5 show Nos. 31 and 36 of this lot. The dams of these calves were common grade cows similar to the Grade Beef Herd previously described. In this experiment all bull calves were sold for veal and only heifers raised. These calves raised for experimental dairy heifers were fed as cheaply as practicable in continuous stable feeding throughout the year. The calves were weaned at one to three days and fed whole milk from the pail for two to five weeks, a somewhat shorter period than Nos. 1 to 30, and then changed gradually to skim-milk. The roughage

fed was the same as with Lots I, II and III, and the same grain mixture was used, but the grain feeding was lighter—economy of production being the primary object as the calves were grades being grown for dairy heifers to be kept on the place. While good growth is desirable in such cases, flesh in not necessary, and slower gain may be satisfactory when the cost is low.

The following tables give the feed consumed, weights and gains, and cost of feed and gain.

TABLE 10.

Feed consumed by Lot IV. No pasture.

No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Beet pulp, lbs.	Grain, lbs.	Cost.
31	148	2,778	531	863	42	149	700	$18 30
32	148	3,051	965	1,032	46	145	829	21 14
33	130	3,004	1,023	1,052	42	149	847	21 19
34	61	2,946	1,150	1,102	42	149	887	21 10
35	62	3,045	1,245	1,129	42	149	886	21 47
36	228	3,423	1,447	770	42	96	579	19 64
37	365	3,146	1,544	750	31	96	570	20 42
38	617	5,702	444	832	.....	184	432	26 08
39	506	5,759	507	885	.....	165	454	25 39
40	565	6,091	576	942	.....	168	487	27 25
41	277	6,476	616	889	.....	149	465	24 68
Average	282	4,129	913	931	26	145	649	$22 41

From this table it may be seen that the amount of whole milk fed is small, from 100 to 150 pounds less per calf than in Lots I, II and III. Skim-milk and roughage showed less variation, but the amount of grain consumed was much less, 649 pounds per head as compared to 1,113, 1,007 and 1,523 pounds for the other three lots.

TABLE 11.

Weights and gains. Lot IV.

No.	Birth weight, lbs.	Gain.				Weight at one year, lbs.
		Period 1, lbs.	Period 2. lbs,	Period 3, lbs.	Period 4, lbs.	
31	71	77	145	117	102	512
32	73	110	129	119	114	545
33	67	118	141	99	119	544
34	84	120	140	107	109	560
35	73	123	122	74	112	504
36	92	85	132	89	76	474
37	77	118	118	91	76	480
38	85	121	150	159	89	604
39	65	104	102	103	113	487
40	83	101	132	166	97	579
41	63	98	110	97	102	470
Average	75.7	106.8	129.1	111.0	100.8	523.5

The average weight at birth was 75.7 pounds and at a year 523.5 pounds, a gain of 447.8 pounds, or 1.22 pounds per head daily. This lot made much smaller gains than the other lots as a result of the light feeding. The greatest gain was made during period two, 129.1 pounds in three months or 1.41 pounds per head daily.

ILLUSTRATION NO. 5.

TABLE 12

Cost of feed and gain. Lot IV.

No.	Cost of feed by periods.					Cost per cwt. gain.				Cost per cwt. at 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
31	$3 65	$5 03	$3 71	$5 91	$18 30	$4 74	$3 46	$3 17	$5 79	$3 57
32	4 67	5 24	5 08	6 15	21 14	4 24	4 06	4 26	5 39	3 87
33	4 75	5 29	5 09	6 06	21 19	4 02	3 75	5 14	5 09	3 89
34	4 34	5 20	5 24	6 32	21 10	3 61	3 71	4 89	5 79	3 76
35	4 20	5 64	5 56	6 07	21 47	3 41	4 62	7 51	5 41	4 25
36	5 57	5 71	3 78	4 58	19 64	6 55	4 32	4 24	6 03	4 14
37	6 29	5 64	3 84	4 65	20 42	5 33	4 78	4 22	6 11	4 25
38	7 36	4 97	6 58	7 17	26 08	6 08	3 31	4 13	8 06	4 32
39	6 47	5 19	6 69	7 04	25 39	6 22	5 09	6 50	6 23	5 21
40	7 64	5 29	6 83	7 49	27 25	7 56	4 01	4 11	7 72	4 71
41	5 62	5 42	6 37	7 27	24 68	5 73	4 93	6 57	7 13	5 25
Average	$5 51	$5 33	$5 34	$6 25	$22 42	$5 23	$4 19	$4 98	$6 25	$4 29

The average cost per head at one year for the eleven calves in Lot IV was $22.42, a much lower figure than for Lots I, II and III, which cost $27.69, $26.78 and $32.53, respectively. The gains, however, were so much less with Lot IV that the cost per cwt. was not greatly different from Lots I and II. Lot IV cost $4.29 per cwt. at one year as compared to $4.32 for Lot I, and $4.20 for Lot II, but was somewhat cheaper than Lot III, which cost $4.79 per cwt. at the same age. The cheapest gains, as before, were made during the second period.

Lot IV was fed to one year of age for an average cost of $22.42 per head, $5.27 less than the average cost of Lot I, $4.36 less than the average cost of Lot II, and $10.11 less than the average cost of Lot III. This cheap method of feeding with Lot IV was practicable as these eleven calves were to be kept on the farm for dairy heifers and large gains and rapid growth were not so essential, but would have been impossible with the calves in Lots I, II and III, which were fed more liberally in order that good weights and finish might be secured at an early age. The cost of production per hundred pounds at one year did not vary as much as the absolute cost of feed.

LOT V.

Lot V consisted of ten calves, Nos. 42 to 51, raised during 1906 and 1907. Of these ten, Nos. 42 to 48 inclusive were pure-bred Holsteins, 49 was a Shorthorn-Holstein cross, 50 and 51 were pure-bred Shorthorns. Illustrations 6 and 7 show Nos. 42 and 46 of this Lot.

The method of feeding was the same as in the preceding cases and as all but one were pure-breds they were fed liberally to give them a good start.

TABLE 13.

Feed consumed in one year, Lot V. No pasture.

No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Green feed, lbs.	Beet pulp, lbs.	Grain, lbs.	Cost.
42	458	2,606	1,313	1,268	148	50	219	1,280	$29 51
43	671	6,123	574	816	495	18	41	634	29 10
44	528	5,500	902	938	660	18	41	721	28 17
45	157	3,122	2,162	1,271	19	.....	234	959	25 42
46	381	2,468	1,262	1,254	148	50	260	1,248	28 57
47	355	2,807	2,030	1,136	48	.....	.....	988	24 84
48	323	5,633	763	737	.....	.....	33	459	22 27
49	410	3,873	2,912	859	64	575	.....	1,168	30 49
50	332	6,092	657	991	.....	.....	148	512	25 19
51	732	6,037	639	913	403	.....	150	575	29 92
Average.....	435	4,426	1,321	1,018	199	71	113	854	$27 35

Table 13 shows an average consumption of 435 pounds whole milk, 4,426 pounds skim-milk, 1,321 pounds silage, 1,018 pounds hay, 113 pounds beet pulp and small amounts of roots and green feed per head up to one year of age, at an average cost of $27.35 each.

ILLUSTRATION NO. 6.

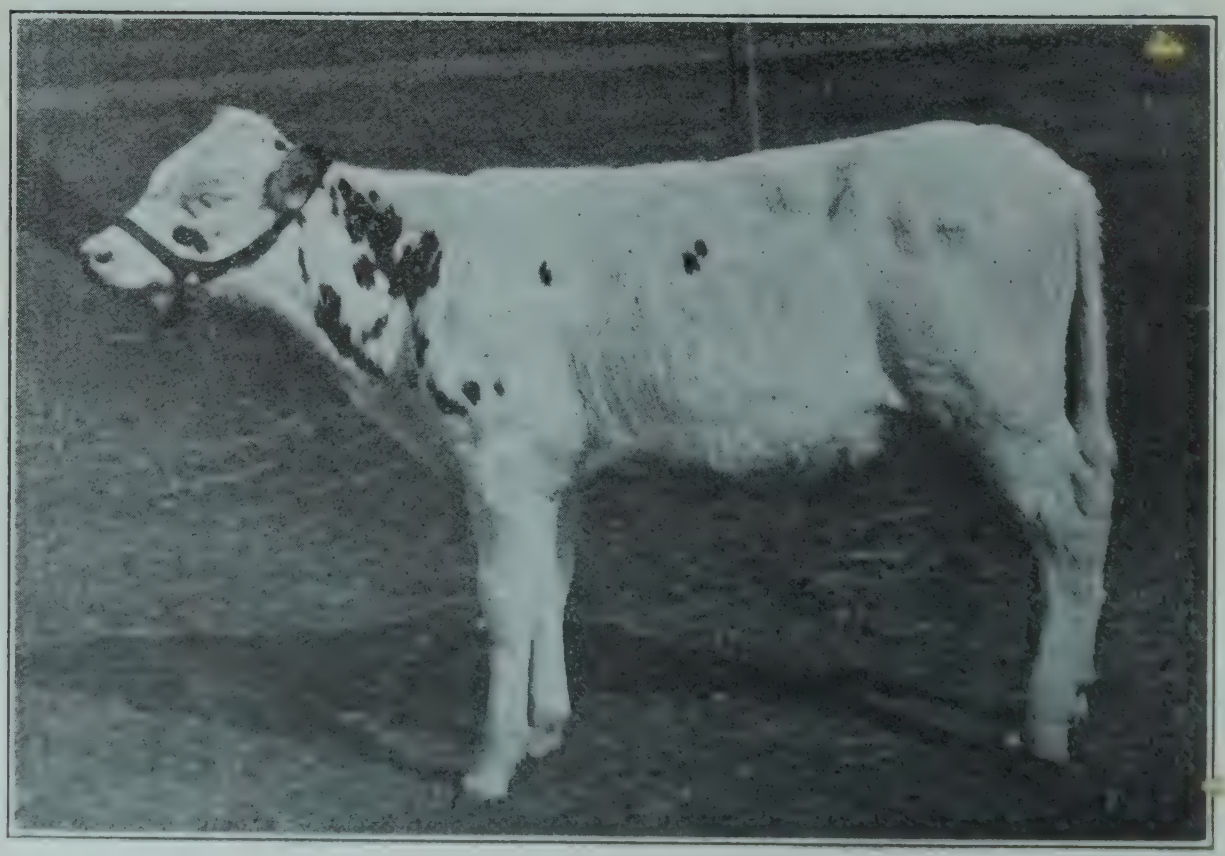


ILLUSTRATION NO. 7.

TABLE 14.

Weights and gains. Lot V.

No.	Birth weight, lbs.	Gain.				Weight at one year, lbs.
		Period 1, lbs.	Period 2, lbs.	Period 3, lbs.	Period 4, lbs.	
42	97	161	164	206	179	807
43	106	130	139	162	144	681
44	90	120	135	156	124	625
45	86	114	214	130	125	669
46	98	172	160	193	177	800
47	94	140	207	128	172	741
48	98	114	203	210	51	676
49	95	165	228	172	170	830
50	77	117	122	138	96	550
51	81	96	116	143	156	592
Average	92.2	132.9	168.8	163.8	139.4	697.1

The average birth weight in Lot V was 92.2 pounds considerably heavier than the preceding lots, as Holstein calves are usually very large at birth. The average weight at one year was 697.1 pounds, a gain of 1.65 pounds per head daily throughout the year, and the greatest gain was made during the second period, 168.8 pounds during the three months, or 1.86 pounds per day.

TABLE 15.

Cost of feed and gain. Lot V.

No.	Cost of feed by periods.					Cost per cwt. gain.				Cost per cwt. 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
42	$6 93	$5 84	$6 80	$9 94	$29 51	$4 30	$3 56	$3 30	$5 55	$3 65
43	8 75	5 03	6 47	8 85	29 10	6 75	3 61	4 00	6 14	4 27
44	7 02	4 95	6 97	9 23	28 17	5 85	3 66	4 46	7 44	4 50
45	5 08	7 98	5 90	6 46	25 42	4 45	3 72	4 53	5 16	3 80
46	6 70	5 74	7 71	8 42	28 57	3 89	3 58	4 00	4 75	3 57
47	6 55	6 30	5 68	6 31	24 84	4 67	3 04	4 43	3 66	3 35
48	5 51	5 48	7 04	4 24	22 27	4 83	2 70	3 35	8 31	3 29
49	6 75	7 09	7 83	8 82	30 49	4 09	3 11	4 55	5 18	3 67
50	5 37	5 30	7 05	7 47	25 19	4 59	4 34	5 10	7 78	4 58
51	8 47	5 42	6 94	9 09	29 92	8 82	4 67	4 85	5 82	5 05
Average	$6 71	$5 91	$6 84	$7 88	$27 35	$5 22	$3 60	$4 26	$5 98	$3 97

The average cost per calf at one year in Lot V was $27.35, with the cheapest feeding period during the second three months and the cheapest gain, $3.60 per cwt. was made during the same period. The average cost of production at one year of age for this lot was $3.97 per cwt., the cheapest of any of the lots so far recorded.

LOT VI.

Lot VI consisted of six pure-bred Holstein calves raised during the years 1904 and 1905, three of which, Nos. 53, 55 and 56, were bulls and the other heifers. They are shown in Illustration 8.

The change from whole milk to skim-milk feeding was made at five to six weeks. Along with the silage and hay they received larger quantities of roots and green feed than any of the lots previously discussed, and they were fed three different grain mixtures during the year. Grain mixture No. 1, the same as was used in all the previous records with calves Nos. 1 to 51, was fed during the first four months; Grain No. 2 during the second period of four months, from four to eight months of age, and Grain No. 3, from eight months to one year. The mixtures used were as follows, all parts given by weight.

Grain No. 1. (Fed up to four months of age.)
- Corn Meal 3.
- Ground Oats 3.
- Bran 1.
- Oil Cake 1.

Grain No. 2. (Fed from four to eight months of age.)
- Corn Meal 4.
- Dried Beet Pulp 4.
- Ground Oats 1.
- Oil Cake 1.

Grain No. 3. (Fed from eight months to one year of age.)
- Corn Meal 5.
- Bran 5.
- Oil Cake 1.

In the feed table following the three grain mixtures are given separately, and the total amount of grain fed for the year is also given. These calves were all registered animals, and were fed liberally, to give good growth and flesh.

TABLE 16.

Feed consumed by Lot VI to one year of age. No pasture.

No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Green feed, lbs.	Grain No. 1 lbs.	Grain No. 2, lbs.	Grain No. 3, lbs.	Total grain, lbs.	Cost for one year.
52	511	3,780	2,228	639	441	931	193	366	629	1,188	$30 34
53	472	3,842	2,593	662	440	987	191	395	623	1,209	30 87
54	451	3,848	2,108	576	436	905	110	348	579	1,037	28 02
55	369	3,980	2,499	584	433	902	123	457	593	1,173	29 31
56	690	3,664	3,358	805	328	932	215	463	412	1,090	32 68
57	586	3,819	3,312	828	398	936	210	463	412	1,085	31 95
Average	513	3,822	2,683	682	413	932	174	415	541	1,130	$30 53

ILLUSTRATION NO. 8.

ILLUSTRATION NO. 9.

The above table shows an average for the year of 513 pounds whole milk, 3,822 pounds skim-milk, 2,683 pounds silage, 682 pounds hay, 413 pounds roots, 932 pounds green feed and 1,130 pounds of grain consumed by Lot VI. A larger quantity of whole milk and silage is shown, and a much larger quantity of roots and green feed.

TABLE 17.

Weights and gains. Lot VI.

No.	Birth weight, lbs.	Gain.				Weight at one year, lbs.
		Period 1, lbs.	Period 2, lbs.	Period 3, lbs.	Period 4, lbs.	
52	100	126	195	156	126	703
53	105	147	228	147	200	827
54	92	113	151	166	151	673
55	101	131	167	158	164	721
56	94	170	212	176	213	865
57	107	186	224	180	153	850
Average	100	145.5	196.1	163.8	167.8	773.1

From Table 17 we find that the average birth weight of the six calves in Lot VI, all of which were pure-bred Holsteins, was 100 pounds. The weight at one year was 773.1 pounds, a gain of 673.1 pounds, and average gain of 1.84 pounds per head daily throughout the year. The second period shows the greatest gain, 196.1 pounds for the three months, or 2.15 pounds per head daily. This weight of 773.1 pounds per head at one year is the heaviest weight reported for any of the lots.

TABLE 18.

Cost of feed and cost of gain. Lot VI.

No.	Cost of feed.					Cost of grain per cwt.				Cost per cwt. at 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
52	$7 53	$6 97	$8 11	$7 73	$30 34	$5 98	$3 57	$5 20	$6 13	$4 31
53	7 41	7 26	8 08	8 12	30 87	5 04	3 18	5 49	4 06	3 73
54	6 72	6 17	7 77	7 35	28 01	5 95	4 08	4 68	4 84	4 16
55	6 22	7 39	8 17	7 53	29 31	4 74	4 42	5 17	4 59	4 06
56	9 22	7 44	8 71	7 31	32 68	5 42	3 51	4 94	3 43	3 78
57	8 59	7 61	8 81	6 94	31 95	4 61	3 37	4 89	4 53	3 76
Average	$7 62	$7 14	$8 28	$7 50	$30 53	$5 29	$3 69	$5 03	$4 60	$3 97

The average cost per head at one year for Lot VI was $30.53, while Lot V, the other lot of pure-breds, cost $27.35 per head, a difference of $3.18 per head in favor of Lot V in cost of feed. The average cost per cwt. at one year was $3.97, exactly the same as for Lot V, showing that while a greater amount of feed was consumed by Lot VI, the gains made were in proportion, and the cost of production remained the same for the two lots. The cheapest gain, $3.69 per hundred pounds, was made during the second period.

LOT VII.

Lot VII consisted of six grade calves raised during 1904 and 1905. These were calves from the Grade Dairy Herd cows, which were bred when purchased, and gave evidence of Shorthorn sires. They are shown in Illustration 7. In this trial the whole milk feeding was continued through a period of about three months before the skim-milk substitution was made, but the results secured did not warrant further trial of this method. Aside from the difference in milk feeding, Lot VII was handled the same as Lot VI in roughage and grain feeding, the three grain mixtures used being the same as those given in connection with Lot VI; viz.: Grain 1 during the first four months, Grain 2 from four to eight months, and Grain 3 from eight months to one year of age.

TABLE 19.

Feed consumed by Lot VII to one year No pasture.

No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Green feed, lbs.	Grain No. 1, lbs.	Grain No. 2, lbs.	Grain No 3, lbs.	Total grain, lbs.	Cost for one year.
58	1,606	2,796	2,416	584	402	863	45	453	555	1,053	$37 91
59	1,365	2,883	2,560	595	406	772	76	466	657	1,199	37 30
60	1,272	3,024	2,638	575	328	857	88	473	662	1,223	36 93
61	986	3,021	2,638	567	398	847	47	527	663	1,237	34 26
62	1,236	3,070	2,911	566	216	733	81	500	532	1,163	35 65
63	1,180	3,064	3,077	570	217	746	91	501	641	1,233	36 51
Average	1,274	2,976	2,707	576	328	803	71	487	618	1,185	$36 43

As above mentioned, Lot VII received a large amount of whole milk, an average of 1,274 lbs. per head, and this materially increased the cost, bringing the total cost of feed for the year up to $36.43, the highest of any of the lots reported.

TABLE 20.

Weights and gains, Lot VII.

No.	Birth weight, lbs.	Gain.				Weight at one year, lbs.
		Period 1, lbs.	Period 2, lbs.	Period 3, lbs.	Period 4, lbs.	
58	73	152	170	160	153	708
59	78	147	160	165	142	692
60	74	137	166	173	142	692
61	75	142	182	174	137	710
62	68	137	193	164	128	690
63	68	140	215	169	153	745
Average	72.6	142.5	181.0	167.5	142.5	706.1

The table of weights and gains shows an average weight at birth of 72.6 pounds for Lot VII, which is approximately the same as for the grades previously reported in Lots I, II, III and IV. The average weight at one year was 706.1 pounds, a gain of 633.5 pounds for the year, or an average of 1.73 pounds daily. The greatest gain was made during the second period, 181 pounds in three months, or 1.98 pounds per head daily.

TABLE 21.

Cost of feed and cost of gain, Lot VII.

No.	Cost of feed.					Cost per cwt. gain				Cost per cwt. of gain.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
58	$14 39	$8 24	$8 31	$6 97	$37 91	$9 46	$4 84	$5 19	$4 55	$5 35
59	13 54	7 44	8 42	7 90	37 30	9 21	4 65	5 10	5 56	5 39
60	13 16	7 26	8 78	7 73	36 93	9 60	4 37	5 07	5 44	5 33
61	10 30	7 48	8 71	7 77	34 26	7 25	4 11	5 00	5 67	4 82
62	12 64	7 00	9 10	6 91	35 65	9 22	3 62	5 54	5 39	5 16
63	12 09	7 09	9 08	8 25	36 51	8 63	3 29	5 37	5 39	4 90
Average	$12 69	$7 42	$8 73	$7 59	$36 43	$8 90	$4 15	$5 21	$5 33	$5 16

The average cost for the year with Lot VII was $36.43, with the highest cost in the first period, $12.69, which is from $5.07 to $7.18 higher than for any other lot during the same period because of the much larger amount of whole milk consumed. The cost of gain during this period was $8.90 per cwt., and the average cost of production at one year was $5.16, considerably higher than any other lot, showing that the added amount of whole milk was fed at a loss.

TABLE 22.

Average amounts and cost of feed per head per lot to one year of age.

Lot No.	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Green feed, lbs.	Beet pulp, lbs.	Grain, lbs.	Cost.
I	416	3,011	907	1,137	224	215	209	1,113	$27 69
II	398	4,125	459	991	.....	.....	142	1,007	26 78
III	444	4,219	723	1,161	148	.....	12	1,523	32 53
IV	282	4,129	913	931	26	.....	145	649	22 41
V	435	4,426	1,321	1,018	199	71	113	854	27 35
VI	513	3,822	2,683	682	413	932	.....	1,130	30 53

The above table gives the average amounts of feed consumed per head by Lots I to VI; Lot VII is omitted as it was handled very differently from the other lots and fed at a greatly increased cost as a result.

TABLE 23.

Total amounts of feed consumed by 57 calves to one year of age, including Lots I–VI with averages.

	Whole milk, lbs.	Skim milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Green feed, lbs.	Beet pulp, lbs.	Grain, lbs.	Cost.
Total feed	23,110	26,616	60,241	57,403	8,474	8,452	6,355	58,889	$1,573 19
Average 57 calves	405.4	3,967.7	1,056.8	1,007	148.6	148.2	111.4	1,033.1	27 59

The average amounts of feed consumed in one year by 57 calves, was as follows, viz.:

Whole milk	405.4 pounds
Skim-milk	3967.7 pounds
Silage	1056.8 pounds
Hay	1007.0 pounds
Roots	148.6 pounds
Green feed	148.2 pounds
Beet pulp	111.4 pounds
Grain	1033.1 pounds

The average cost per head at one year for 57 calves was $27.59.

Note—Lots I, II, III and V contained ten calves each, while IV and VI had eleven and six head respectively. On account of this variation in numbers computations made from the average data of the lots in Table 22 could not agree with the grand averages secured from the total figures given in Table 23, which are correct. The same will apply to a comparison of the four following tables.

TABLE 24.

Average weights and gains by lots to one year.

Lot No.	Birth Weight, lbs.	Gain.				Weight at one year, lbs.
		Period 1, lbs.	Period 2, lbs.	Period 3, lbs.	Period 4, lbs.	
I	76.4	138.0	164.0	126.3	139.2	643.9
II	80.0	131.0	141.0	148.0	139.0	629.0
III	72.0	136.0	168.0	165.0	141.0	682.0
IV	75.7	106.8	129.1	111.0	100.8	523.5
V	92.2	132.9	168.8	163.8	139.4	697.1
VI	100.0	145.5	196.1	163.8	167.8	773.1

The above table gives the average birth weights, average gains by periods and weights at one year.

TABLE 25.

Total weights of 57 calves with averages

	Birth weight, lbs.	Gain.				Weight at one year, lbs.
		Period 1, lbs.	Period 2, lbs.	Period 3, lbs.	Period 4, lbs.	
Total weights	4,639	7,427	9,015	8,235	7,702	36,917
Average 57 calves	81.3	130.3	158.1	144.4	135.1	647.6

The average birth weight, weight at one year and average gains during the four periods for the whole number of 57 calves was as follows, viz.:

Birth weight	81.3 pounds
Gain Period, 1	130.3 pounds
Gain Period, 2	158.1 pounds
Gain Period, 3	144.4 pounds
Gain Period, 4	135.1 pounds
Weight at one year	647.6 pounds

The birth weight represented 12.5 per cent of the weight at one year. The per cent of gain in each period to the total gain for the year was as follows: 1st period, 22.9 per cent; 2nd, 27.8 per cent; 3rd, 25.4 per cent and 4th, 23.7 per cent.

TABLE 26.

Average cost of feed and gain in Lots I to VI.

Lot.	Cost of feed.					Cost per cwt. of gain.				Cost per cwt at 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
I	$6 96	$6 32	$6 27	$8 15	$27 69	$5 06	$3 87	$4 96	$6 01	$4 32
II	6 50	6 05	7 02	7 21	26 78	4 99	4 31	4 86	5 58	4 20
III	7 19	7 44	9 08	8 81	32 53	5 36	4 43	5 66	7 05	4 79
IV	5 51	5 33	5 34	6 25	22 42	5 23	4 19	4 98	6 25	4 29
V	6 71	5 91	6 84	7 88	27 35	5 22	3 60	4 26	5 98	3 97
VI	7 62	7 14	8 28	7 50	30 53	5 29	3 69	5 06	4 60	3 97

The above table shows the average cost of feed per head in Lots I to VI by periods and also the average cost of gain by periods.

TABLE 27.

Total cost of feed by periods, cost of gains and averages for 57 calves.

	Cost of feed.					Cost per cwt. of gain.				Cost per cwt. at 1 year.
	Period 1.	Period 2.	Period 3.	Period 4.	For 1 year.	Period 1.	Period 2.	Period 3.	Period 4.	
Total	$379 93	$358 67	$400 52	$434 25	$1,573 30	.....	.....	.....	.....	.....
Aver. 57 calves	6 66	6 29	7 02	7 61	27 59	$5 18	$4 04	$4 95	$6 00	$4 27

24.1 per cent of the cost of feed for the year came in period 1, 22.8 per cent in period 2, 25.5 per cent in period 3 and 27.6 per cent in period 4.

The following is the average cost per cwt. gain by periods:

For 1st period	$5 18
For 2nd period	4 04
For 3rd period	4 95
For 4th period	6 00

METHODS OF CALF FEEDING.

The calf may be allowed to suck its dam a few times or for the first day or so but should then be put in a separate pen. If the calf is strong and the cow's udder is in good condition it is best to separate them the first or second day, as the cow is more easily reconciled to the separation and the calf can be taught to drink more readily than if it has sucked the cow for some time. If the calf is weak, it is better to leave it with the cow, as it will feed oftener and grow stronger, or if the cow's udder is inflamed, the calf will help to bring it back to proper condition. In any case the calf should be given the first milk or colostrum, as it has a stimulating and corrective effect upon the system.

When the calf is taken from the cow it may not drink at first, but after the omission of a feed it becomes hungry and as a rule can be taught to drink quite easily. The calf should be given the milk from its dam rather than from another cow, as changing from one to another is likely to throw the digestive system out of balance and result in scours. For the first few days it is best to feed the calf three times a day, though it is not absolutely necessary. The milk should be fed in a clean pail, directly after milking, while still at body temperature. For an average sized calf, weighing 70 to 75 pounds at birth, 8 to 10 pounds a day, divided equally between the feeding periods, is sufficient to begin with. If the cow is a high tester, that is, gives milk rich in butterfat, it is advisable to feed that portion of the milk which is first drawn from the udder, as it will have a lower butterfat content and will be less apt to cause digestive disorders than the richer portion. The amount fed should be increased gradually and great care taken to avoid over-feeding. At the end of two weeks the calf may be given 12 to 16 pounds daily, divided equally between the morning and night feeds. In case scours develop the feed should be reduced immediately, cutting down at least one-half, and, if necessary, medical treatment resorted to. The time for beginning the substitution of skim-milk in place of the whole milk will vary depending upon conditions. Whole milk feeding is necessarily expensive, and should not be continued longer than necessary to produce good results. When feeding for dairy heifers to be kept and grown on the farm, the skim-milk supply may begin at two or three weeks of age, but where it is desired to produce heavier weights at an early age, it is better to feed whole milk up to four or five weeks before starting the substitution. The change should be made gradually so that the calf's stomach may adjust itself to the different conditions without trouble. Begin by replacing one pound of whole milk with an equal amount of skim-milk at each feed the first day, and replace two pounds the second day, and so on. In that way if a five-weeks-old calf was getting 16 pounds of whole milk a day, 8 pounds at a feed morning and night, it would take eight days to make the substitution complete, and the calf would be changed entirely to the skim-milk ration when it was six weeks old.

The skim milk should be as nearly the same from day to day as possible, and should always be sweet. Many farmers fail in the attempt to raise skim-milk calves with satisfactory results simply because of the filthy and unsanitary methods employed. The milk should be warmed to body temperature especially with the younger calves during winter. The amount of skim-milk fed may be increased to 20 pounds per day, but it is not generally profitable to feed in larger quantities. The length of time to continue feeding milk will vary with conditions, but ordinarily it does not pay after the calf is seven or eight months old, except when the supply is plentiful and would otherwise be wasted. When it is two or three weeks old the calf can be taught to eat a little grain by throwing a handful in the pail after it has finished drinking the milk. The grain should not be put in the milk as the calf will swallow it with the milk without much mastication and it will not be properly digested. The calf will soon learn to look for the grain, and at five or six weeks of age should be eating a pound or so a day. A good grain mixture for feeding in this way may be made of three parts corn meal, 3 parts ground oats, 1 part bran and 1 part oil cake, by weight, and the amount fed should be increased gradually so as to allow from one-half to one pound per day per one hundred pounds weight of the calf. This is liberal feeding, and should keep the calf in good condition and give good gains. Lighter feeding may be followed in many cases with good results and less cost, as in raising dairy heifers on the farm.

Hay feeding should be started along with the grain. Alfalfa, if it is available, or good, bright clover hay of fine quality, is best for calves. Alsike clover is relished by the young calf and makes an excellent feed. It is a good plan at haying time to select some of the best and finest of the clover and put it aside especially for calf feeding. Coarse, woody clover or timothy contains too much crude fibre and indigestible material to be fed to young animals. Alfalfa and the clovers, especially the former, are very rich in protein, the most essential element for growth and development of the body. Hay feeding should be increased gradually like the grain, but the calves may be fed all they will eat up clean. Silage and roots may be included in the ration with good results but should not be fed until the skim-milk ration is well established, and should be dropped from the feed in case scours develop.

Fall calves may be turned on grass in the spring as soon as possible, but some grain feeding should be continued even then, depending upon the condition of the pasture. In the dry summer months of July and August, when the grass is short and dead, some green feed, if available, would be a valuable addition. The calves should have access to water after they are three or four months old, as the milk furnished will not be sufficient for them to drink, and during hot weather, especially, they will drink considerable quantities of water in addition to the milk.

STABLING.

The illustration following shows a very convenient method for stabling calves, and is the one in use at the college. The calves are kept in good sized pens, several calves together, allowing much more chance for exercise than when each calf is confined separately in a small stall. The calves are allowed to run loose in the pens, except at feeding time, and are then easily fastened in the stanchions while drinking. They should be kept in the stanchion for a half hour or so, and fed grain, as they are sure to suck each other if released immediately after drinking. The young calves should be kept in separate pens up to two or three weeks of age, as it is a difficult matter to keep them from sucking before they learn to eat hay and grain. By fastening them in the stanchions in this way each calf may be fed separately and get only its own share of grain. The calf pen should be well lighted and clean and should open into an exercising yard where the calves may be turned out whenever the weather permits.

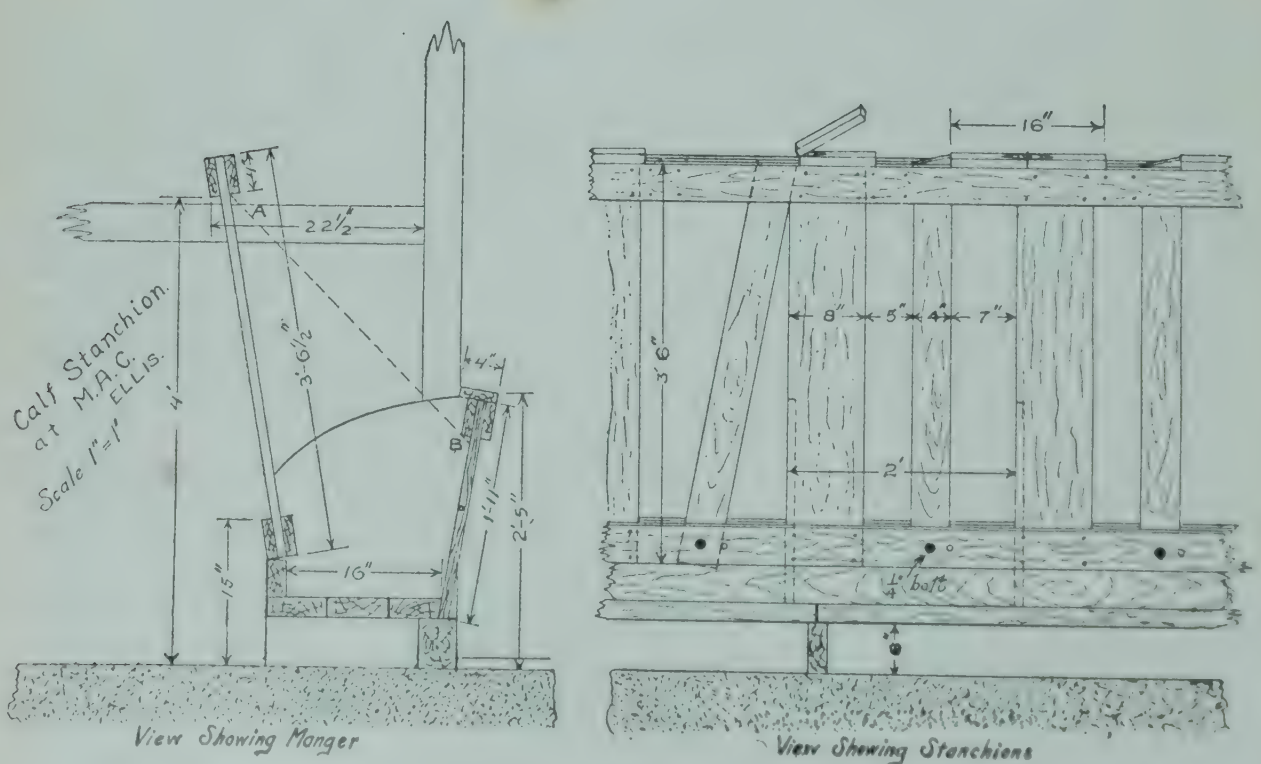


ILLUSTRATION NO. 10.

INSECTS OF FIELD CROPS.

Bulletin No. 258.

INTRODUCTION.

The present bulletin is the third of a series dealing with the insects affecting different classes of crops. It deals with the insects of field crops in Michigan. The less common insects have been omitted in order to avoid confusion.

Many facts have been drawn from the writings of others, mainly from those of Professor F. M. Webster, of the National Bureau of Entomology, and from those of Professor S. A. Forbes, of the University of Illinois, whose work on corn insects stands in the lead.

It must be borne in mind that many crops, such as beets, corn and beans, are raised both in the garden and in the field. In order to avoid repetition, many insects already noticed in Bulletin 233, "Garden Insects," have been briefly mentioned and reference given to the earlier bulletin. Especially is this true if the remedial measures are the same, when applied either on a small or on a large scale.

The illustrations are from various sources. Credit is given in each case where the source is known.

The first number of this series is special bulletin 24, "Insects Injurious to Fruits in Michigan." The second is bulletin 233, "Insects of the Garden." The present bulletin constitutes the third.

Always send specimens of insects or of their work to the

Entomologist of the Experiment Station,
East Lansing, Michigan.

INSECT AFFECTING FIELD BEANS.

WORKING ON THE ROOTS.

SEED-CORN MAGGOT.

(*Pegomya fusciceps.*)

One of the causes of failure of germination of seeds in the ground is the seed-corn maggot, otherwise known as the bean-maggot. It is said to attack the seed of peas, corn and beans, and also to work on a varied list of plants including pumpkin, cotton, orange, artichoke, strawberry, cabbage, beets, onion, mustard, and other plants.

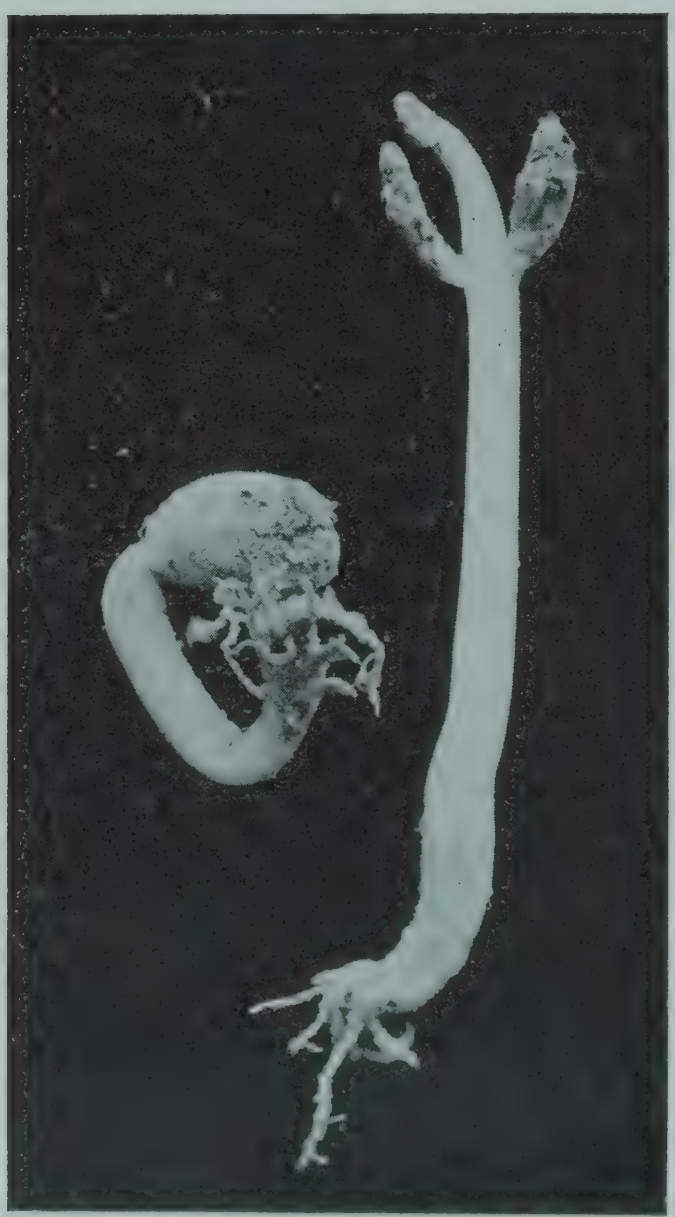


Fig. 1—Young bean plants affected by bean-maggot, enlarged. (Author's illustration.)

The writer has seen it at work on beans, both in Minnesota and in Michigan.

The attack has been most serious when made just after the germination of the seed. Later attacks are less apt to kill outright, though naturally they are bound to diminish the crop. With the young beans the attack is likely to occur just as the beans are nicely appearing above the ground. The cotyledons are blackened and the young central shoot often is shrivelled and dead. Maggots are often to be found in the decaying cotyledons or in the fleshy stems beneath the surface of the soil. This occurs during the first part of July: On July 22nd the adult flies appeared in our cages.

The maggots appear very much like those of the onion maggot and those of the cabbage mag-

got, being white, tapering, and about one-fourth of an inch long. The adult fly looks like a minature house fly, being about one-fifth of an inch long.

The seed-corn maggot is credited with breeding in decaying vegetation and also in fresh manure.

REMEDIAL MEASURES.

The standard repellants, sand and kerosene, and carbolic acid emulsion (see Bul. 233, Mich. Agr. Exp. Sta.) can be used when the beans are in the garden, just as in the case of radish and onion maggots. However, in the field, such methods are hardly practicable. The avoidance of freshly applied stable manure and the substitution of commercial fertilizers during the year that beans are raised on a given piece of ground, should prove beneficial when the maggot has once made trouble. Of course beans should never be planted where the maggot is known to have been recently, nor in fact should they be planted in very close promimity to a recent outbreak.

WORKING ON LEAVES AND STEMS.

FLEA-BEETLE ON BEANS.

(*Systena blanda.*)

Several flea-beetles attack field beans. Probably the most troublesome is the pale-striped flea-beetle. It is only during hot, dry summers that these tiny creatures make their attacks, but at such times they are likely to appear in myriads in fields of beans and sugar beets, as well as in all sorts of garden truck.

The name flea-beetle is suggested by their habit of jumping when disturbed, very much like a flea.

The beetles themselves are only about one-eighth of an inch in length and creamy in color, with thin, longitudinal stripes of light brown on the wing-covers. The larvae are slender, thread-like creatures, white in color with yellowish heads. They feed underground on the roots of weeds for the most part.

Fig. 2.—Pale striped flea-beetle, enlarged. (Author's illustration.)

The effect of many tiny beetles eating holes in the foliage of tender young bean and beet plants is to shrivel the leaves and, if the plants are very small, to kill them outright.

REMEDIES.

The beetles winter as adults, which at once suggests the burning of rubbish about the farm, in fence corners, etc.

Bordeaux furnishes a very valuable repellant for all flea-beetles and bordeaux with arsenate of lead should prove very effective against the flea-beetle on beans. When used on more hardy plants, bordeaux and paris-green might be perfectly satisfactory, but the foliage of the bean is very easily 'burned" by insecticides, and arsenate of lead is the safest stomach poison we have.

BLISTER BEETLES.

See Bul. 233, Mich. Agr. Exp. Sta., pp. 11-13.

CUT-WORMS.

See insects affecting corn.

WORKING IN THE SEED.

THE BEAN WEEVIL.

(*Bruchus obtectus.*)

The beetle of "buggy beans" is a small, robust, hard-shelled creature about one-eighth of an inch in length. It is brownish-grey in color, and carries its head bent at right angles to the body. The wing-covers are noticeably shorter than the abdomen, as is the case with most of the family to which it belongs.

There are several generations each year, the eggs of one generation being laid on the growing pods in the field, either upon the outside of the pod or in holes cut with the jaws. The larvae enter the growing beans, often several in a single bean. Here they continue to work after the crop is harvested and later in the dried beans, rearing several generations each year and continuing until very little more than a shell remains of the bean. They also attack dried peas and are credited also with feeding on several other seeds, however, beans and peas are the only seeds thus far attacked in Michigan. Beans and peas which have been attacked by the bean-weevils are unfit for seed, since even if they germinate, they produce sickly plants of small value. Furthermore, when one uses "buggy" seed, in which the pests are alive, one places the insects in just the best surroundings for their continued welfare. It therefore behooves the farmer to treat the seed carefully before planting, in order to kill the beetles in all the seed or else to separate and use only sound seed.

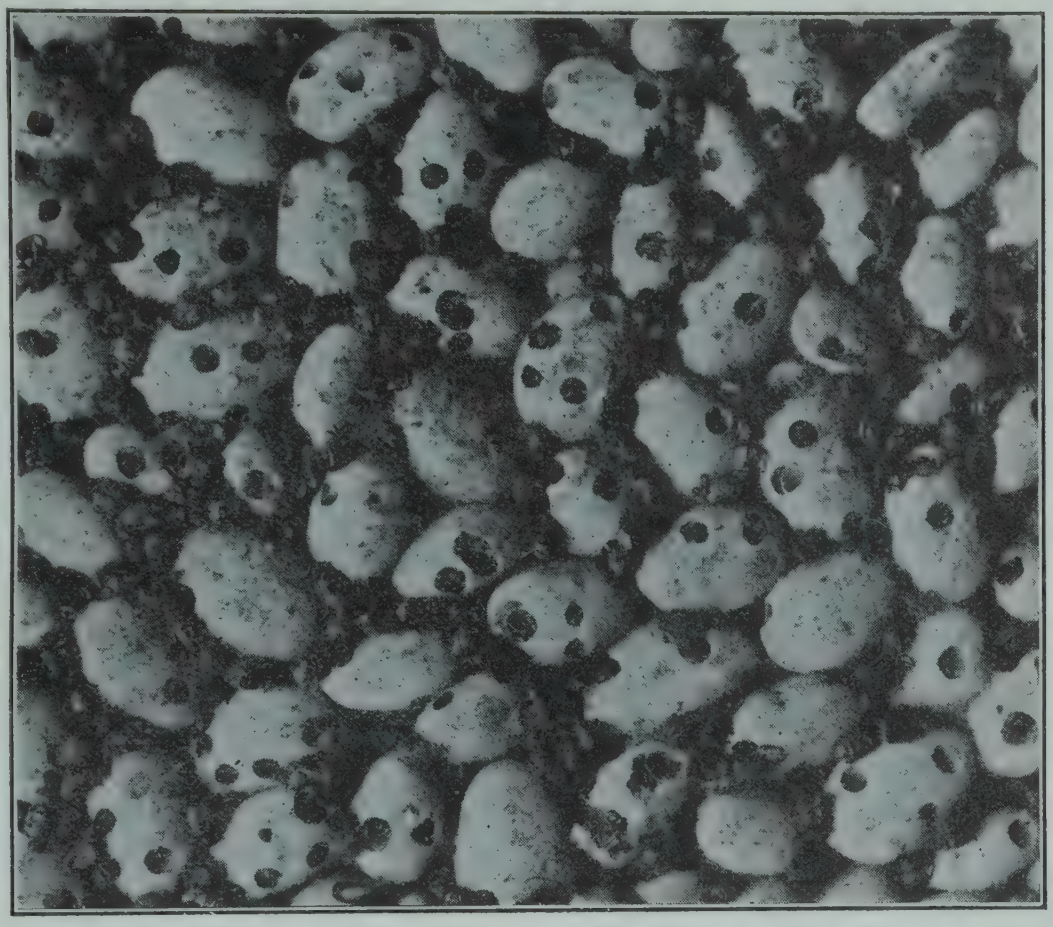


Fig. 3.—Beans infested with bean-weevil, slightly enlarged. (Author's illustration.)

REMEDIES.

It has been found that sound seed will sink in water and that infested seed is apt to float. It is quite easy to separate badly injured seed from the sound by merely floating it out in the water. However fumigation with carbon disulphide is the most reliable remedy and this may be done in the fall or whenever the seed is seen to be suffering. A time should be selected when the weather is not too cold, since the poisonous fumes are less efficient in extremely cold weather.

THE FOUR-SPOTTED BEAN WEEVIL.

(*Bruchus quadrimaculatus.*)

This comparatively new pest is an old enemy of cowpeas and has recently been introduced into Michigan. It also works in the common bean and, like the common bean weevil, it works indefinitely in the stored seeds until nothing of value is left. As this beetle is larger than the bean weevil, its work is comparatively rapid.

The appearance of this beetle is well shown by Fig. 5. Like the bean weevil, this creature starts work in the field, coming into the granary with the harvested beans, or it may gain access after the beans have been stored away.

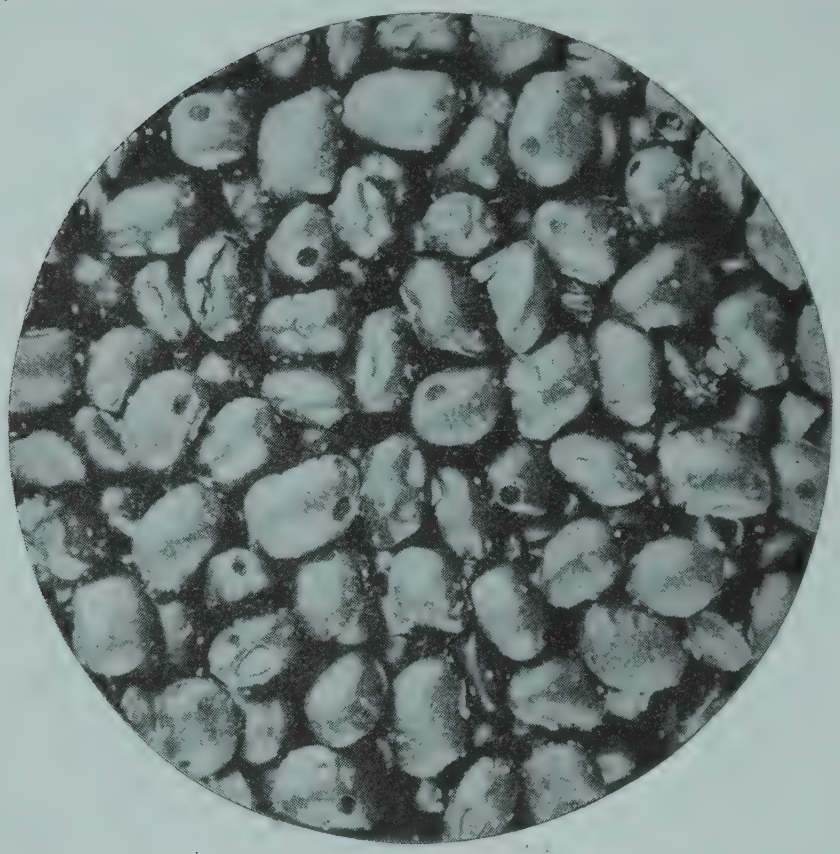


Fig. 4.—Work of four-spotted bean-weevil, on cowpea, slightly enlarged. (Author's illustration.)

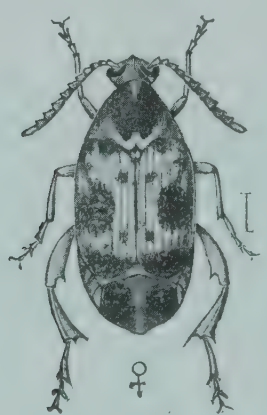


Fig. 5.—Four-spotted bean-weevil, enlarged. (After Chittenden, Bul. 8, U. S. Bureau of Ent., U. S. Dept. of Agr.)

REMEDIES.

Fumigation of the seed, during a warm spell, with carbon disulphide is the best remedy thus far discovered.

INSECTS AFFECTING FIELD-BEETS.

For cut-worms, see Insects of Corn.
For other insects, see Bulletin 233, Mich. Agr. Exp. Sta., pp. 6-15.

INSECTS AFFECTING CLOVER.

WORKING IN THE ROOTS.

CLOVER ROOT-BORER.

(*Hylastinus obscurus.*)

Undoubtedly the most destructive enemy of clover with which we have to contend is the root-borer, a creature, which was unknown in our state up to about twenty years ago, but which has now become well distributed over the state. Originally from Europe, the root-borer was accidentally imported into America without the natural enemies with which it had to contend in its native home. Here it has found the land of promise and fulfilment.

Fig. 6.—Clover root-borer, much enlarged. (After Riley.)

Usually the first acquaintance with this pest is made sometime after the field has been cropped for one season. The field will not look just right and a few plants will be pulled to see if the roots are healthy. Affected plants are apt to break off at the level of the ground. On examination the roots will be found to be tunnelled, the cavities being blackened and often containing the tiny beetles or the grubs, sometimes eggs will be found if the tunnels are examined with a good lens. Further search is apt to reveal a good many plants in the same condition.

Seldom, if ever, does the root-borer work in clover plants before they are a year old,—that is, one year from the spring following the sowing of the seed, usually with grain in this state. The first spring directly following seeding, the roots are to small to attract them, and after that they escape until the following spring, owing to the habit of the beetle of migrating only at the spring season, usually in early May. There is but one generation each year.

Mr. G. C. Davis, formerly of this station, describes the life-history of the beetle in bulletin 116. The winter is passed in the tunnel, for the most part, in the adult stage. Migration occurs usually in early May, new fields are attacked and tunnels made, so that by the latter part of May the eggs are laid, packed away in the dead parts of the roots and covered up with refuse. Toward the latter part of summer the larvae change to pupae in the burrows, to become adult beetles by fall. Both larvae and pupae feed on the substance of the roots.

Mammoth clover suffers most of all. Common red clover (June clover) nearly as much, and Alsike less.

The beetles themselves are very small, being rather less than one-eighth of an inch in length. They are reddish-brown in color. The eggs are smooth and white, and the larvae are white with yellowish-brown heads.

REMEDIES.

We find one encouraging feature in the whole situation, in that the beetle never attacks until the plants are one year old. True, they have not done much in the way of growing by that time, but they have made a start and are ready to produce hay. During the season after seeding, the field usually escapes with a minimum of injury, but after that time there is apt to be trouble. We must be content with one season's crop of clover, instead of a succession of seasons of clover meadow produced by re-seeding, as was customary before the root-borer came. It forces us to keep up a short rotation with clover as with everything else.

Now as to the plowing of the field. Professor Webster, then of the Ohio station, advised plowing immediately after cutting, and before the larvae had pupated, if possible, exposing the roots to the drying influence of the wind and sun, thus drying out the larvae and starving them.

WORKING IN THE STEM.

CLOVER STEM-BORER.

(*Languria mozardi.*)

Of minor importance as a crop destroyer is the stem-borer. The adult is a smooth, polished and slender beetle, about one-fourth of an inch long, with red head and thorax and with dark, steel-blue wing-covers. This beetle lays its eggs inside the clover stem in the spring, and the larvae from the eggs tunnel up and down through the stem, maturing and emerging in the fall. They injure the plant somewhat by weakening the stem. It is an insect to be found scattered over the clover fields, but we have never seen it in numbers sufficient to do appreciable injury.

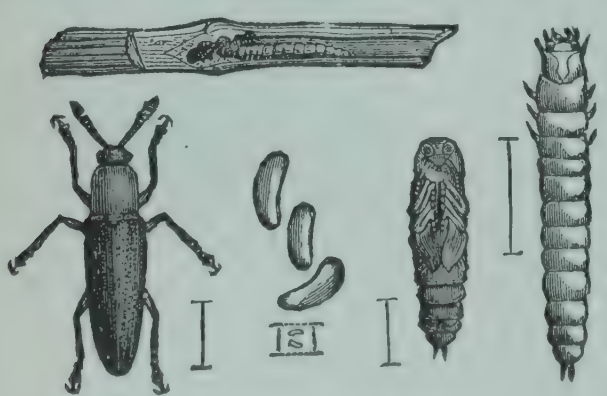


Fig. 7.—Clover stem-borer, enlarged. (After Comstock.)

WHITE-CLOVER STEM-WEEVIL.

(*Sitones flavescens.*)

On one or two occasions reports of marked injury to white clover have been made, accompanied by a number of specimens of the small snout beetle known as *Sitones*. The letter, accompanying one of these lots of specimens from Battle Creek, states that the enclosed culprits were

rapidly destroying freshly made lawns. The appearance of the beetle would never lead one to suspect it. It is a yellowish-brown snout-beetle, about three-sixteenths of an inch in length, and with a short, thick beak. The body and the legs are covered with very short, dense hairs, those on the underside sometimes having a coppery tinge.

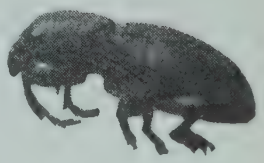


Fig. 8.—White clover stem-weevil, enlarged. (Original.)

The habits of this creature have been carefully observed by Professor F. M. Webster and reported in the year-book of the United States Department of Agriculture for 1886, pp. 580-2. Professor Webster reports severe injuries to white clover and to Alsike; circular or semi-circular pieces being eaten out of the leaves by adult beetles.

The larvae are described as about three-sixteenths of an inch in length, with a dirt-colored head and white body, tapering quite markedly at the hind end. The work of the larvae is normally in or on the stems, where they feed on the soft inner parts.

The winter is said to be passed in the partly grown larval stage, pupation occurring early in spring. Occasionally, Professor Webster says, adults may hibernate. On July 5th adults were plentiful, and larvae that were no doubt the larvae of this creature, were reported present in the soil.

REMEDIES.

Mr. W. D. Regus, of Battle Creek, reports that a layer of six inches of tobacco waste spread over the ground failed to kill these pests. It is likely that a drenching with kerosene emulsion may prove useful in case of infested lawns.

WORKING ON THE LEAVES.

CLOVER BUTTERFLY.

(*Eurymus philodice.*)

Closely resembling the common cabbage-butterfly, in size and general appearance, is the yellow butterfly or clouded sulphur. Many believe that the cabbage butterfly is either white or yellow, but this is a mistake. The cabbage-butterfly is white and gray, or white and black, and the yellow one is an altogether different creature, living in its larval condition on clover, and its relatives; vetch, lupine, peas, etc. The larva resembles the cabbage-worm somewhat, being green with either yellowish or pinkish stripes, bordered below with black on the sides.

Fig. 9.—Clover butterfly.

There are three generations each year, but the injury wrought by

these dainty yellow creatures is not known to be anywhere near as serious as that inflicted by their white relatives, the cabbage butterflies, perhaps because they are distributed over such wide areas and because their work is more obscure.

CLOVER DRASTERIA.

(*Drasteria erechta.*)

This measuring-worm is fairly common in clover fields. The larva is brown and gray, striped, and about one and one-fourth inches long. It progresses by a method of looping steps like a measuring worm. When full-grown it spins a cocoon in a little nest prepared by tying a few leaves together, wherein it changes to the pupal condition to emerge soon as an adult moth. The moth is prettily marked with grayish and brown. It measures about one and one-half inches from tip to tip of its extended wings. The flight of this moth is jerky and quite rapid. When disturbed it flies a short distance and usually dives behind some plant, going into hiding, where it remains some time unless disturbed. There are several generations each year, but in spite of this the increase is seldom sufficient to destroy a crop.

Fig. 10.—Clover drasteria.

Among the remedies suggested for its destruction is fall plowing, preferably in October. We would add that plowing is really not necessary in the majority of cases, because the injury is usually slight.

CLOVER LEAF-HOPPER.

(*Agallia sanguineolenta.*)

A small leaf-hopper about one-eighth of an inch in length is the clover leaf-hopper. Professor Herbert Osborn and H. A. Gossard, then of the Iowa station, describe this creature as feeding voraciously on clover, beside several other plants, such as sugar beets, cabbages, rutabagas and blue grass. It is an insect of minor importance, and is one of the pests that hibernates in rubbish. When it demands attention, clean culture is indicated.

CLOVER LEAF-BEETLE.

(*Phytonomus punctatus.*)

Among the important enemies of clover must be reckoned the leaf-weevil, a snout beetle which arrived here only in comparatively recent years, and whose native home is Europe. The adult beetle is dull-brown in color, much lighter on the sides, and covered with minute, yellowish hairs. It has a stout beak, or snout, curled downward and backward under the body, but clearly visible in profile. The beetle is plump, and about three-eighths of an inch in length. It is quite commonly seen during the autumn on roadside plants, on sidewalks and on buildings, etc. For the most part, at least, the winter is passed in the larval stage, the

young grubs or larvae attacking the fresh clover plants in the spring, feeding on the leaves. At night they venture boldly out and devour the leaves, but during the daytime are more or less concealed near the bases of the plants. In appearance these larvae are almost slug-like, footless, and green in color with a lighter stripe running down the back. They reach the length of about half an inch when full-grown, at which time they spin beautiful fine-meshed, lace cocoons, usually, though not always, at the surface of the ground. The cocoons are elliptical and about three-eighths of an inch in length, and of a light-greenish color. In July and later the beetles appear, feeding also on the clover plants.

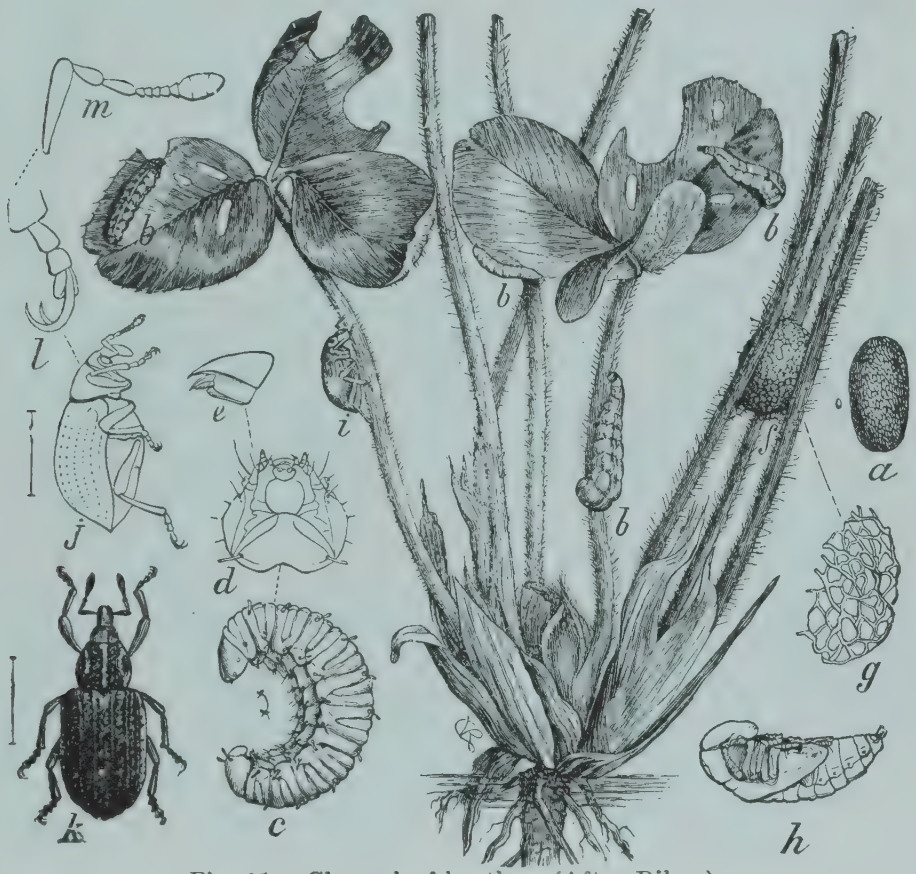


Fig. 11.—Clover-leaf beetle. (After Riley.)

NATURAL ENEMIES.

Fortunately for us the clover-weevil, which has all the characteristics of a first-class pest, is kept in check by a fungus disease, a fungus that flourishes on the living bodies of the larvae and kills them in great numbers. Curiously enough, larvae attacked by the disease are impelled to climb up on spears of grass around which they wrap their bodies and die. The spores or seed-like bodies of the fungus are thus thrown to some distance, and falling on other larvae spread the disease. Epidemics of the disease (*Empusa sphacrosperma*) usually follow attacks of the weevil, so that it is ordinarily held in check and reduced to small numbers before much harm has been done. Large numbers are sometimes killed at once, so many as to show plainly on the tips of the spears of grass, when one looks along the tips from a level near the ground. The

writer has seen the color of a patch of clover and timothy changed from a bright green to a marked greyish tint by the dead bodies of the larvae, each on its grass leaf.

Now this is all very satisfactory thus far. The fungus ordinarily keeps the beetle in check, and if it stopped at this point all would be well. But unfortunately the dead bodies of the larvae are filled with the substance of the fungus, and this is said to be poisonous to stock if eaten in sufficient quantity. Mr. G. C. Davis, formerly of this station, reports the serious illness of cattle which was quite clearly due to eating

Fig. 12.—Larvae of clover-leaf weevil killed by fungus, enlarged. (Original.)

quantities of the dead larvae, although no fatalities resulted. We have since that time received accounts of similar occurances. For this reason it will be well to avoid pasturing stock in fields full of the dead larvae until they have had time to shrivel and fall to the ground.

CLOVER MITE.

(*Bryobia pratensis.*)

The clover mite is not a true insect but a near relative. It is responsible for much of the whitening of the foliage of clover and some other plants. It is a tiny creature with eight legs. The color is dark red. Minute spherical eggs are laid on trees in the fall, where they are often

the cause of alarm among fruit growers, who are apt to consider them some form of scale. The main reason for disliking the clover mite, however, is not because of injury done to clover, as that is too obscure to be much felt. The tiny mites have a habit of crawling into buildings in the spring and in the autumn, where they get on furniture, books and tables. They are so fragile that it is next to impossible to even brush them off, they crush so easily leaving a red stain. This is especially disagreeable when they crawl into open books or between papers. A closing of the books or a shifting of the papers is sure to result in tiny, red blotches.

The best way of keeping these mites out of buildings is to spray the outside of the foundation walls with kerosene, or to coat them with a narrow band of some sticky mixture, such as tangle-foot, printer's ink, or something similar.

It is probable that the lime and sulphur sprays, in common use at present, will help to destroy the mite by destroying the eggs.

DESTRUCTIVE PEA-LOUSE.

(*Nectarophora destructor.*)

Pea-growers, especially those raising peas for canneries, sometimes have difficulty with a green plant-louse of small size, which collects in astonishing quantities on the vines. The same creature is to be found living, at almost any time, on clover and crimson-clover. It is impossible to do much in the way of control when the insect is on clover nor is it often necessary. For method of controlling the louse on peas, see bulletin 233 of this station.

Platypena scabra.

Mr. G. C. Davis, formerly of this station, records finding *Platypena* in Michigan. He says, the moth is smaller and darker than that of the *Drasteria,* and the caterpillar is whitish-green with faint yellowish-green stripes along its sides. Mr. Davis describes its method of progression as something of a looping movement. It is said to be very active.

WORKING IN THE HEADS.

CLOVER-HEAD CATERPILLAR.

(*Enarmonia interstinctana.*)

Mr. G. C. Davis records the presence of this pest in our state. South of us, in Iowa, it has been, at times, a first-class pest. According to Professor Gillette and Professor Osborn, there are three generations each year with sometimes a partial fourth generation. The tiny moths lay their eggs in the clover heads and the larvae, usually one to a head, feed on the forming seeds, destroying all or part in each head. The winter is passed in the larval stage and pupation occurs early in the

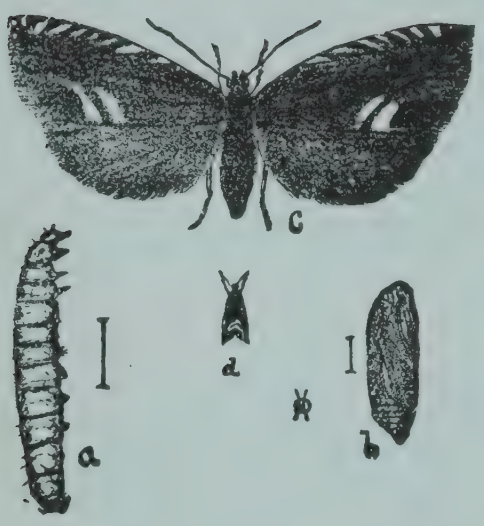


Fig. 13.—Enarmonia interstinctana, much enlarged. (After Osborn.)

spring. The caterpillar is said to be greenish-white or pale yellow without markings, with a brown head, and sixteen legs. It is said to be about one-fourth of an inch long. The adult moth is brown.

REMEDIES.

Should this insect become of sufficient importance with us, as it has in Iowa, it is pointed out by Professor Osborn that spring plowing (done before the end of April) or fall plowing will destroy the third generation. Early cutting of the first crop, as is recommended for the seed-midge, should destroy the first generation, and where this is common practice it is unlikely that the head caterpillar will become very serious.

CLOVER THRIPS.

(*Phleothrips niger.*)

At any time before the middle of the summer, a clover head, if torn apart, is likely to reveal a number of tiny red or black creatures, which run quickly about in attempts to hide. They are thrips. The immature thrips are bright blood-red, becoming darker as they grow older, the adults being black. The general appearance is quite similar to that of the oats thrips. See page 25. These little creatures are so small and are provided with such feeble mouth-parts, fitted for scraping only, that individually they are capable of doing only a slight amount of injury. In the aggregate it is reasonable to assume that they must blight quite an appreciable number of heads or parts of heads, but thus far no one has devised a practical method of controlling them. Fortunately they are most plentiful early in the season at a time when it does not make so much difference. All thrips thrive best in hot, dry weather.

WORKING IN THE SEED.

CRIMSON CLOVER-SEED CHALCID.

(*Bruchophagus funebris.*)

When crimson-clover was introduced into America, it was hoped and believed that we had a substitute for red clover that would at least be free from the enemies of red clover. The trial proved, however, that crimson clover seed was preyed on by a pest, more troublesome than those of red clover seed, and further that the new pest was liable to spread from the crimson to the red clover. The new pest was first noticed in Michigan in 1899 on the twelfth of July, great quantities being found escaping from newly-threshed crimson clover seed. A close examination of the seed showed the kernels to be hollowed out by the tiny creatures.

each infested seed containing a tiny, black, wasp-like winged insect, belonging to a family most of the members of which are parasitic in their habits.

There are two broods each year. The tiny chalcids are slightly more than one-sixteenth of an inch in length, and jet-black in color. The hulls from which they emerge show each a little, round hole through which the insect has come. If this were the whole story no one would grieve much, but, unfortunately Dr. A. D. Hopkins, then of the West Virginia Station, reports that they work in developing seeds of red clover as well. It is not at all impossible that on some of the occasions where the red-clover crop has failed, this newer pest has been to blame. The writer has searched many times and has had many samples of clover seed sent in from all over the state for the purpose of finding the cause of such failure, but thus far has been unable to find the characteristic hulls, possibly because they are so light as to be blown out by the separator.

Dr. Hopkins reports that the insect winters " in seed left in the open field, evidently in the larval stage." This would suggest fall plowing when the presence of the pest in a given field is established and when such practice is practicable. *Professor F. M. Webster suggests burning stems and hulls after hulling and the destruction of all outstanding clover heads, as a remedy worth trying.

CLOVER-SEED MIDGE.

(*Cecidomyia leguminicola.*)

When we consider the large amount of clover seed raised annually in Michigan, the depredations of the tiny seed-midge become of alarming importance. So small and frail is this creature that one almost doubts its ability to injure anything. Nevertheless, most of the failure of June clover and mammoth clover, to seed is due to it, and possibly to the clover-seed chalcid with which it is sometimes confused.

The life-history of this creature is well known, and fortunately we are able to so time our cutting as to take advantage of the creature and thus secure a crop of seed most of the time. A brief review of the life-history is as follows:

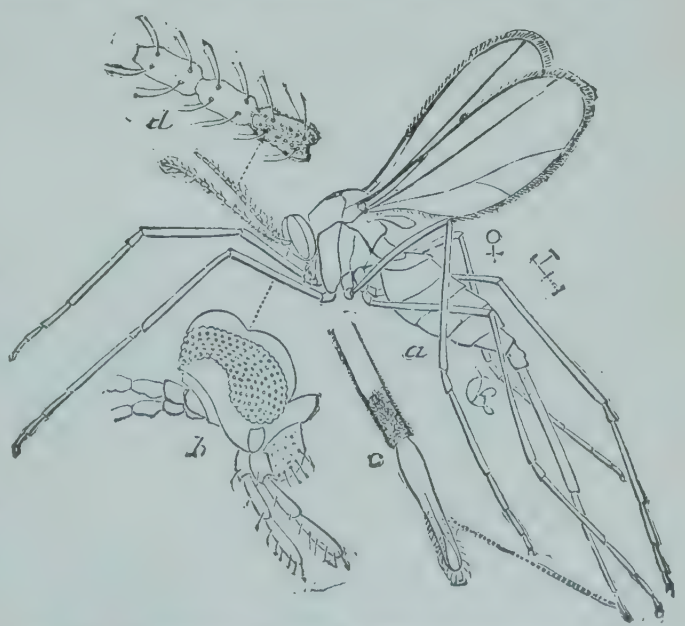


Fig. 14.—Clover-seed midge, greatly enlarged. (After Riley.)

The light-yellow eggs are laid just inside the flower tubes at the time when they are beginning to show color. After a short time the eggs turn red in color, hatch, and each one produces a tiny maggot which travels down inside its flower tube to attack

*Circular No. 69, Bureau of Entomology, Dept. of Agr.

the soft seed forming at its base. This seed is known as the ovule at this stage, and it furnishes just the right sort of food for the maggot when in this soft condition. Later, when the ovules commence to get hard, they are safe from attack since the mouth parts of the maggot are feeble.

In the ordinary course of events, when the first crop of clover is cut late, the maggots descend to the ground, bury themselves, and change to puparia, which stage corresponds to the cocoon stage of moths, later they transform to minute flies, much smaller than mosquitoes, which are just in time to lay their eggs in the coloring clover-blossoms of the second crop. These if undisturbed reach the pupal stage by winter, in which condition they remain until spring, ready to produce the crop of flies which once more lays its eggs in the first crop of clover.

In appearance these flies are very frail little creatures, brownish in color and very small, being only a little more than one-eighth of an inch long. They swarm about the clover-heads during the egg-laying season, but are not often observed because of their small size and dull color. Usually the presence of the midge is unsuspected until after threshing time, when the tiny pink or salmon colored larvae are found mixed with the threshed out clover seed. Sometimes as much as one-fourth or one-third of the product is made up of tiny maggots, which if not understood are very alarming to the farmer, who suspects them of having designs on his seed. All suspicion of wrong doing is unfounded, however, since all the harm was already done before the clover was cut, the maggots being powerless to injure the dry, hard seed.

REMEDIES.

As already stated, the development of the second crop of clover flowers and the development of the second generation of midges have to occur simultaneously in order for the young seeds to be in just the right condition for food at the time when the young maggots hatch out from the eggs. This is likely to occur if the first crop is cut during the time when the flowers are turning brown. If, on the other hand, we cut the first crop just as the color is beginning to appear, then the second crop of clover is pushed ahead of its normal time a week or more, and the young ovules or seeds become hardened before the second generation of midges have emerged and are ready to lay their eggs. Also many larvae and pupae are no doubt destroyed by the early cutting, and the ones that do succeed in finding places for their eggs, have to put up with inferior and belated heads, few in number. Now it is well known among many clover growers that early cutting of the first crop is the best insurance possible for a crop of clover seed.

During the past few years, the presence of the crimson clover-seed chalcid has been reported in June clover in other states; and failure to get a good crop of seed, when there seems to be no other explanation, may be due to the presence of this pest. It is needless to say that all volunteer clover should be destroyed.

WORKING IN THE HAY.

CLOVER-HAY WORM.

(*Hypsopygia costalis.*)

Supposing that a crop of clover successfully evades the leaf-beetle, root-borer, and all its other enemies, and that it has been stowed away in the mow or stack. One would think that at last it should be free from danger. There is, however, one more insect pest to which it is exposed, viz., the clover-hay worm.

This pest, the larva of a pretty little miller or moth, feeds on the dried hay, eating a small amount, but tying up by means of webs.

Fig. 15.—Clover- hay moth. (After Riley.)

Fig 16.—Clover-hay moth, enlarged. (Author's illustration.)

and thereby ruining, many times that amount of good hay. It prefers the bottom and edges of a mow to work in, and here it is likely to bind the hay into felted masses, which stock refuses to accept. It spins a silken thread wherever it goes and besides this spins a cocoon of a tough nature, tucking it away in the hay, and between the hay and boards, giving the hay the appearance of being molded.

The brownish caterpillar or larva is very active when captured or disturbed, wriggling away and dropping suspended by a single thread which it spins as it falls.

REMEDIES.

The hay worm remains over from year to year in the old hay and to control it we have only to feed out all the old hay and clean the mow before each new crop is put in. In the case of stacks, burn up the refuse and build the new stacks at a little distance. If only a little refuse remains in the bottom of the mow, clean it out and burn. Never put new clover hay on top of old when the hay worm is present or has been recently.

CLOVER MEALY-BUG.

(*Dactylopius trifolii.*)

Occasionally we find old clover fields infested by a mealy-bug, which lives on the roots. This tiny sucking insect lends its aid in impoverishing the plants, usually in company with the root-borer. Especially is this true in sandy land and in fields that have stood several years in June clover or mammoth clover. We have never seen fields seriously injured by this creature.

It is usually kept in check automatically by rotation in this state, where clover is commonly used for green manuring.

INSECTS AFFECTING CORN.

INSECTS WORKING ON THE ROOTS.

SEED-CORN MAGGOT.

(*Pegomya fusciceps.*)

See insects affecting beans.

CORN ROOT APHIS.

(*Aphis maidiradicis.*)

No less than six species of plant lice are described by Dr. S. A. Forbes* as working on corn roots in Illinois. Of these the corn root aphis *Aphis maidiradicis* is by far the most important. It sucks the sap from the roots, impoverishing the plants, and doing the most injury when the plants are small. Dr. Forbes points out that the welfare of these root-lice depends largely on the care bestowed on them by ants, several species of which attend them and protect the eggs over winter, besides caring for the lice during the growing season. In Illinois, the best results seem to follow rotation, together with late fall plowing in order to break up the nests of the ants.

Fig. 17.—Corn-root aphis, enlarged. (After Forbes.)

The aphids feed on other plants and like especially smart-weed.

*Thirty-first annual report of the Ill. State Board of Agr.

pigeon-grass, and purslane. Heavy applications of fertilizer are said to help the plants to recover from the early attacks. The aphids spread quite freely, but are worse when corn follows corn than when corn follows something else.

Thus far the corn root-louse has not attracted attention in Michigan.

CORN ROOT-WORMS.

(*Diabrotica longicornis* and *D. 12-punctata.*)

Two corn root-worms occur in Michigan. One of these is the Southern Corn Root-worm, *Diabrotica 12-punctata,* which is a first class corn pest, in parts of some of the states south of us. As it has not, thus far, been guilty of depredations in Michigan, we will merely refer to Dr. Forbes' full account of the creature,* and state that it is said to bore, when in the larval stage, into the stalk beneath the surface of the ground, sometimes killing the plant out-right, but oftener retarding it so that it is still green when frost comes.

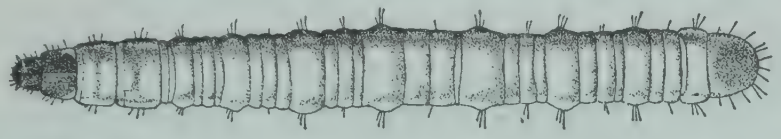


Fig. 18.—Southern corn-root worm larva, enlarged. (After Forbes.)

The Northern Corn Root-worm, *Diabrotica longicornis,* tunnels in the roots themselves, and is, when abundant, said to be even more serious. Strange to say, however, it has not been recorded as doing harm in Michigan as yet, probably because of the system of rotation in common prac-

Fig. 19.—Southern corn-root worm, enlarged. (After Forbes.)

tice here. Rotation being the remedy recommended by Dr. Forbes. These root-worms are small grubs, white in color, and about four-tenths of an inch in length in the case of the Northern species, and about fifty-six-one-hundredths in the case of the Southern species. They are both fully discussed by Dr. Forbes, as above cited.

* Twenty-first annual report of the Illinois State Board of Agriculture.

WHITE GRUB.

(*Lachnosterna.*)

See Bul. 233, Mich. Agr. Exp. Sta. p. 53.

WIRE-WORM.*

(*Agriotes mancus* et. al.)

Low ground and more especially mucky ground, is apt to be infested with wire-worms. These are slender, yellow, little creatures, cylindrical in form, and in size varying from half an inch to more than an inch in length. All have hard, polished skins amounting almost to shells, and six short legs just behind the flattened heads, besides a sucker-like false-foot on the last segment. Wire-worms usually feed on the roots of grains, corn and other grasses, though they will not refuse potatoes when occasion offers. There are many species to be found in Michigan, and while one may prefer corn, another wheat, and so on, they may all be considered as injurious, except those found in rotting wood, and treated together as far as we are concerned. The adults are the common snapping-beetles or click-beetles, the little fellows that jump up into the air with a click, when placed on their backs. These beetles lay the eggs from which the wire-worms hatch, and the wire-worms in turn become click-beetles after passing through a chrysalis stage in their little earthern cells in the soil. It is probable that two years are required by the larvae to attain maturity. The winter is passed in little cells in the soil in some cases, while in others the adult beetles emerge in the fall and hibernate.

Wire-worms are primarily insects of grassland and the fact that they require two or three years to develop helps to explain why it is that they are often worse the second year after grass than they are the first, most of them being full-grown at that time.

Fig. 20.—Click-beetle, adult of wire-worm, slightly enlarged

REMEDIES.

In corn, the most noticeable injury is to the seed after planting, though the larvae also feed on the roots after the corn is up. A long series of experiments by Professors Comstock and Slingerland of Cornell University, failed to show any practicable method of treating the seed so as to prevent injury by wire-worms. They did show, however, that late fall plowing killed many of the pupae and adults by breaking open the earthen cells in which they were. They failed also to kill the wire-worms by any of the commercial fertilizers or insecticides, unless these were used in excessive quantities.†

* Taken from Bul. 233, Mich. Agr. Exp. Sta., p. 51.
† Bul. 33, Cornell University Experiment Station.

Professor S. A. Forbes, State Entomologist of Illinois, proposes a rotation of crops in which clover shall always follow grass, and corn shall always follow clover. Plow the grass in early fall, and sow clover, either with oats, wheat or rye. Allow the clover to stand two years and follow with corn.*

On general principles it is well to use wood-ashes where obtainable, because of their tonic effect on the plants. It is understood, of course, that these practices are recommended for aggravated cases of wire-worm infestation and not for regular use in the absence of the pest in dangerous numbers.

WORKING ON THE STALK.

CORN AND TIMOTHY BILL-BUG.

(*Sphenophorus sculptilis.*)

Fig. 21.—Corn Bill-bug. (Author's illustration.)

The timothy and corn bill-bug is a small beetle that habitually works in timothy, where its work is naturally more or less obscure. When, however, corn follows infested timothy, or when corn is planted near infested timothy, it is likely to be attacked.

While this beetle is more common in states south of us, it has in Michigan occasioned almost total loss of isolated fields of corn. The beetles are less than one-fourth of an inch long, and are black. They belong to the group of snout-beetles. In young corn they tunnel directly into

* Rep. State Bd. Agr. 1893, p. 50, containing 18th Rep. State Ent. of Illinois for 1891-2.

the plants just above the crowns, causing the plants to wilt and usually to die.

Fortunately the beetle produces but one generation each year, and the injury, so far as corn is concerned, is done by the adult beetles alone.

REMEDIES.

While the bill-bug is known best by its work on corn, it is really timothy that suffers the most from its ravages. Working as it does in the bulbous roots of the timothy, it is able to pass unnoticed unless it occurs in very large numbers. Here in the timothy bulbs, are passed the immature stages, the adults emerging at just the right time to attack the young corn. The moral is not to plant corn after timothy in places where one has reason to fear the presence of the beetles. When the beetles have once come out and done their work in the corn, there seems to be no danger from re-seeding, for there is but one generation each year and the beetles require timothy for their early development.

CUT WORMS.*

Just about the time that the danger from crows has abated somewhat, the young sweet-corn is often called upon to withstand an attack by cut-worms. There are striped cut-worms, dark, light, glassy, greasy and many other sorts, each belonging to a different species, and each developing into its corresponding moth. The moths or millers are nocturnal in their habits, and are spoken of as owlet-moths because of their habits and the shape of their heads.

Cut-worms naturally work on sod land, and for this reason, it is well to avoid planting corn, tobacco, tomatoes or anything else especially liable to their attacks directly after grass. Then too, the great majority of our cut-worms pass the winter in a partially grown condition, and when spring comes, and the sod and roots are replaced by a compara-

Fig. 22.—Cut-worm showing larva, pupa and adult. (From Saunders Insects Injurious to Fruits)

tively smaller number of corn plants, the worms are hardly to be blamed for feeding on them. Sod land, then, has its disadvantages when used before a crop liable to attack by cut-worms. It is also a menace when adjacent to a corn-field, for the "worms" will travel quite a distance from their breeding grounds in order to get at their favorite food. They work at night, traveling on the surface of the soil, and cutting off the plants low down at or just below the soil level. They cut off much more than they can use and then retire before daybreak, burrowing lightly and hiding often near the plant just cut off. One "worm" will forage night after night and destroy many times as much food as

* From Bulletin 233, Mich. Agr. Exp. Sta., p. 57.

could be eaten. One can not help wondering at its wasteful habits. It has been suggested that the food is cut in order to let it wilt before it is eaten. Wet food does not seem to agree with some caterpillars, neither does that which is too vigorous and turgid. It is not unreasonable to suppose that much of the food is cut in order that it may wilt and be ready for future use, rather than from mere wanton destructiveness. As has been stated many of the cut-worms pass the winter in a partially grown condition, just beneath the surface of the soil. Occasionally, in winter, during a sudden thaw, the larvae will crawl up on top of the snow, being driven upward by the water from the melting ice and snow. In such cases they seldom get back into winter quarters, but perish as soon as it freezes again. The writer has seen the snow thickly dotted with cut-worms on such occasions, both here and in Minnesota. Many parasites feed on them and shrews and birds devour quantities.

REMEDIES.

The measure that has been most successful in the past, is the use of poisoned baits, when the trouble is on a large scale. On a very small scale, other methods are more effective. Of the baits used, clover is the favorite. A goodly pile of clover should be cut, and while it is still fresh and green, it should be wet down with paris-green and water, using about half a pound of poison to a barrel of water, then, late in the afternoon, so that it will keep fresh as long as possible, twist bunches of this wetted clover in wads, more or less compact, and throw out over the field at short intervals. If the field to be protected be near a field in sod, then place an extra amount on the threatened side. The cut-worms love clover and oftentimes they will hide under such wads of fresh green food in the morning after a night's travel, eating a little of the poisoned food before hiding away. Poisoned pieces of turnip will do if clover is not to be had.

Poisoned bran, sweetened with a little molasses and made into moist balls the size of a plum, has been recommended, and Mr. Sirrene, of the New York State Experiment Station, recommends dry bran mixed with dry paris-green, sowed on the surface of the soil by means of a hand drill. In any case do not use such baits of bran unless stock and poultry are excluded or when partridge and quail are likely to get it, and do not expect to find the dead worms in the morning unless you are willing to sift the top soil for some distance about each bait, for the pests always bury themselves before dying. The only way to judge of the death of the larvae is by the cessation of their work.

The habit of passing the winter in a partially grown condition or in the egg state, at once suggests fall plowing as a palliative measure, unless it be undesirable for cultural reasons.

WORKING ON THE LEAVES.

OATS THRIPS.

(*Anaphothrips striatus.*)

See insects affecting oats.

WORKING IN THE EAR.

FALL ARMY-WORM.

(*Laphygma frugiperda.*)

This insect is a close relative of the army-worm, but one which does its worst work in the fall. It also works on green-corn in the cob occasionally.

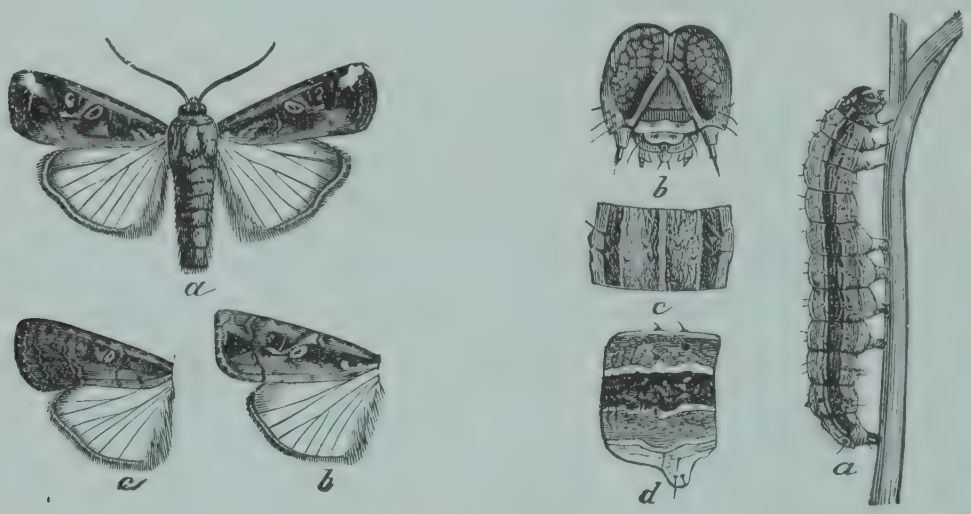


Fig. 23.—Fall army-worm, larva and adult, showing details. (After Prof. Lawrence Bruner.)

For further information see Bul. 233, Mich. Agr. Exp. Sta., p. 66.

BUMBLE FLOWER BEETLE.

(*Euphoria inda.*)

Fig 24.—Bumble flower-beetle. (Author's illustration.)

See Bulletin 233, Mich. Agr. Exp. Sta., p. 61.

CORN EAR-WORM.

(*Heliothis obscura.*)

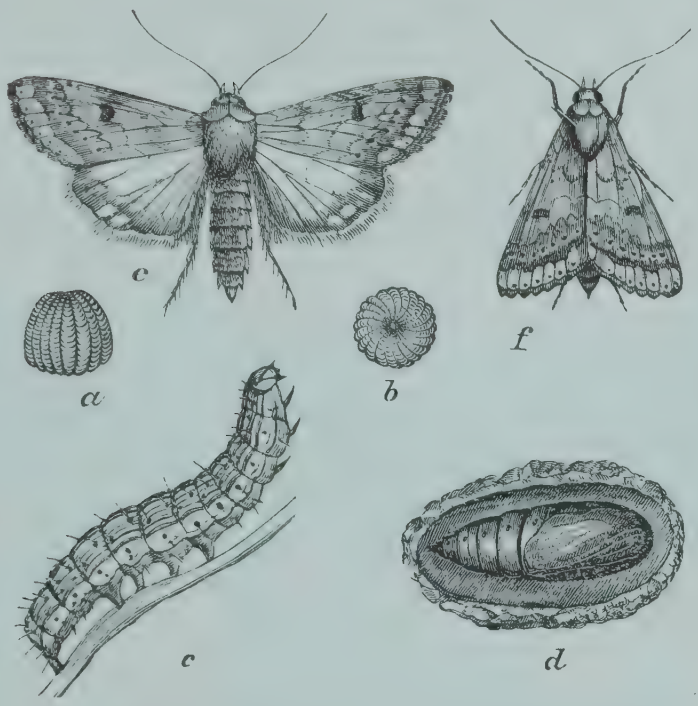


Fig. 25.—Boll-worm or corn ear-worm. (After Riley, Third Mo. Rep.)

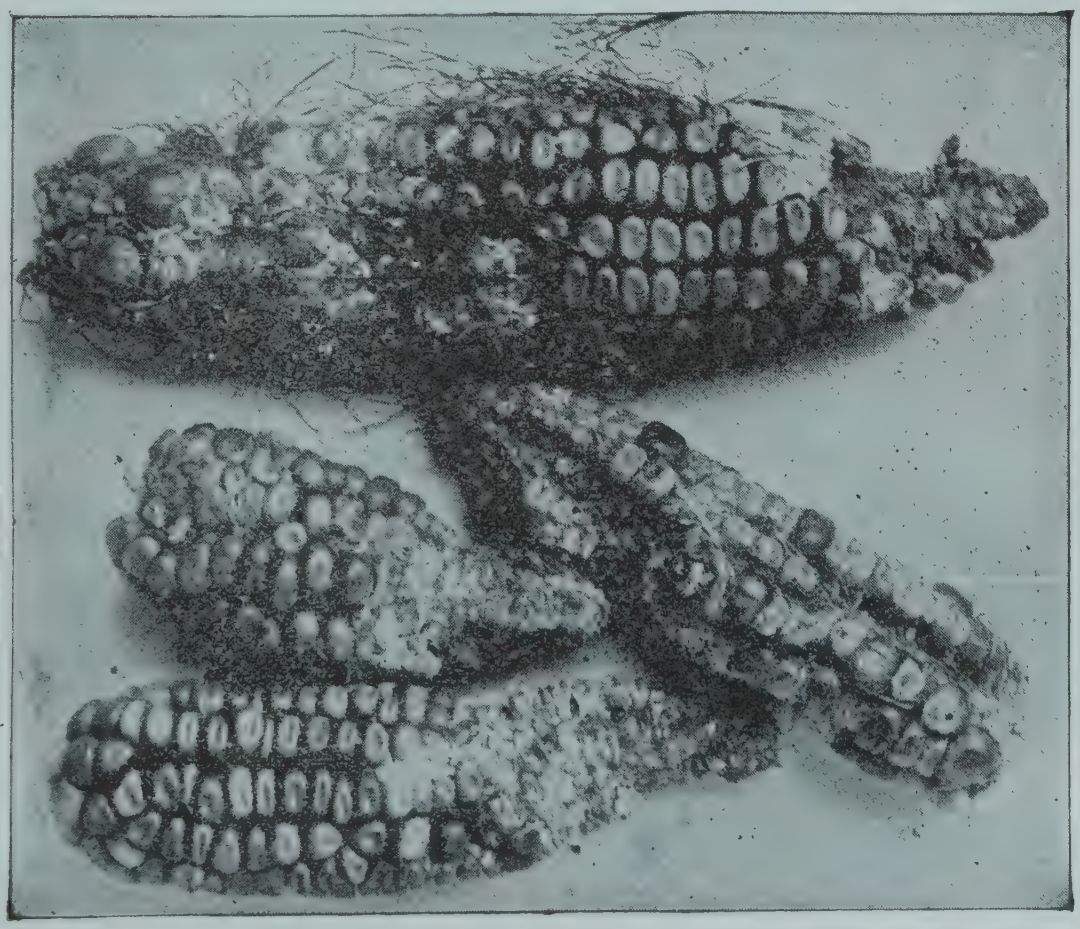


Fig. 26.—Work of corn-ear worm. (From Prof. J. B. Smith, State Ex. Sta. of N. J.)

See Bul. 233, Mich. Agr. Exp. Sta., p. 60.

WORKING IN THE SEED.

ANGOUMOIS GRAIN-MOTH.

(*Sitotroga cerealella.*)

Some two centuries ago, a small moth was introduced into America from France. Since that time it has become pretty well acclimated and has spread over a wide territory. It invaded our state in the early '90's. At the present time, the moth has gained a very undesirable reputation as an enemy of stored grain. It works both in the field and in the granary on wheat, corn, oats, rye, barley, sorghum-seed, and peas.

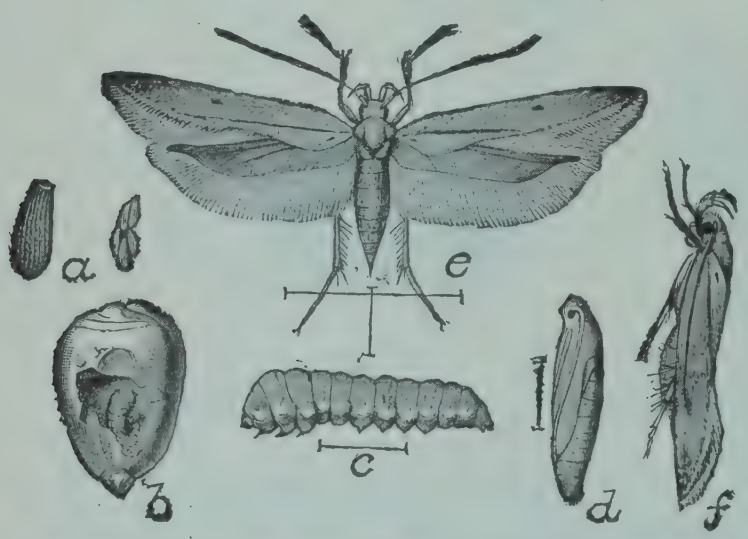


Fig. 27.—Angoumois grain-moth. (From F. H. Chittenden, U. S. Dept. of Agr., Farmers' Bulletin No. 45.)

In appearance the moth is a delicate little creature, larger than a clothes moth, but measuring only a little more than half an inch across the extended wings. The wings are narrow and the color buffy or yellowish-white, marked with a little dark brown or black.

The moths are said to go into the field at the time when the grain heads out and to deposit eggs in the opening heads. A new generation of moths develops from these eggs about harvest time and the eggs and young larvae from this generation go with the grain into the granary, where they feed inside the kernels and produce another generation during late September. The number of succeeding generations depends largely on the climate. There may be one or several.

The pest is easily overlooked, since it works inside the kernel out of sight. The outside shell of the grain remains intact except for the small hole through which the adult emerges.

Grain badly infested is distasteful to horses, besides being of little use for milling purposes. Most, if not all, of the injury to grain in Michigan, thus far, has been to oats stored in comparatively warm places.

REMEDIES.

Professor John B. Smith, of the New Jersey Experiment Station, who has had abundant opportunity to experiment with this creature, recommends that threshing be done as soon after harvest as possible and that the grain be put in bulk in tight bins or sacks. If the grain heats more than usual, it may be an indication that the larvae are at work. In such cases it is well to treat with carbon bisulphide using the liquid at the rate of one pound to 100 cubic feet of air space in the bin. Sometimes more is needed, especially if the weather is cold.

In using carbon bisulphide, always remember that the gas is poisonous if breathed, and extremely explosive if ignited. Also remember that cold weather interferes with its efficiency. See directions on page 50.

THE LITTLE GRAIN MOTH.

(*Tinia granella.*)

One of the least common of the grain moths is the Little Grain Moth of Europe. It is about the size of a clothes-moth, one-fourth of an

Fig. 28.—Work of little grain-moth in field corn, slightly enlarged. (Author's illustration.)

inch or a little less in length, but differs in having spotted wings. The ground-color is creamy white with a suggestion of pearl, spotted with brownish-black.

In its work the Little Grain Moth resembles somewhat the Angoumois moth, but it spins silken threads all through the grain, binding the kernels together by a web. They, too, live inside the kernels. The eggs are laid both on small grain and on corn in the field, and the young continue to breed in the stored grain, raising several generations each year. We have received this insect working in stored corn in the cob, where it was the cause of severe losses. We have also bred it from corn-stalks stored over winter in a barn in Lansing, as well as what seems to be the same thing from drying fungi (Morels) here at the College.

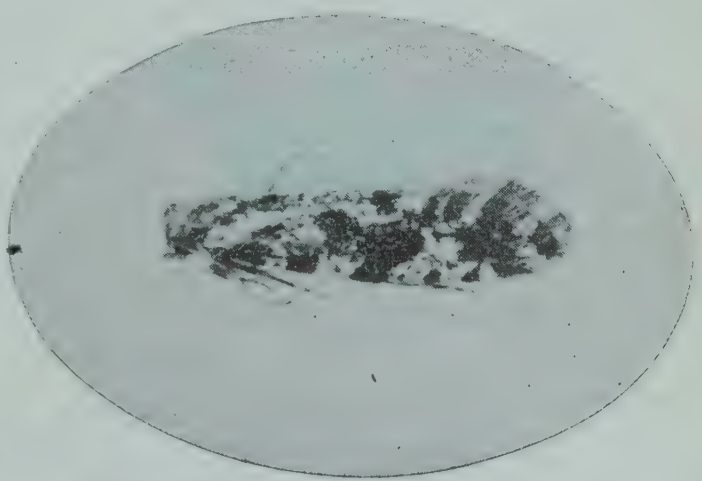


Fig. 29.—Little grain-moth, greatly enlarged. (Author's illustration.)

REMEDIES.

The fact that the pest seems to be better suited to the North than to the South, and that it feeds on other foods than grains themselves, makes its possibilities for producing trouble more worthy of consideration. The best method of control thus far at our command is the same as that directed against the Angoumois moth.

There are other moths which work in stored grains, beside the two mentioned, but no others are known to the writer to work in the field as well, in Michigan. The present bulletin deals only with pests which work in the field.

INSECTS AFFECTING HOPS.

See Bul. 233, Mich. Agr. Exp. Sta., p. 32-33.

INSECTS AFFECTING OATS.

INSECTS WORKING ON THE FOLIAGE.

ARMY-WORM.

(*Heliophila unipuncta.*)

At more or less extended intervals, Michigan is invaded by the army-worm. The worst invasions usually follow cold, wet springs, as such weather seems to favor the "worm," probably by interfering with its parasites. These invasions come at such long intervals for any one

Fig. 30.—Army-worm adult moth. (After Riley.)

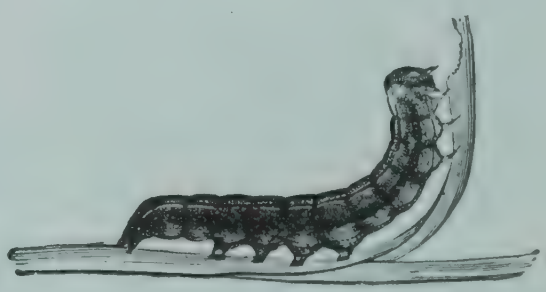


Fig. 31.—Army-worm.

locality, that we are apt to forget all about them from one time to another, and as they come almost without warning, they catch us unprepared. Often severe losses occur before we get our bearings.

As the name implies, this pest appears in armies, and usually the trouble starts from a brush-heap or from rubbish in low, wet ground, which seems to be chosen by the adult moths as suitable for egg-laying. The larvae or caterpillars spread from the place of their birth and attack grasses or grains, feeding at night or during lowery weather, and preferring oats to anything else.

They have the habit of cut-worms, that is, they cut off the leaves from the plants, allowing them to fall to the ground and to wilt, where they are eaten. As they hide away during the daytime, becoming active at night, and as they leave the tops until the last, they often remain undiscovered until half or two-thirds grown. When the leaves are disposed of, the caterpillars cut off the heads, and at this time the owner of the field discovers that something is wrong. The destruction goes rapidly on until, if not prevented, the caterpillars migrate or "march."

This marching reminds one, once more, of the movement of an army. The caterpillars start together and the great majority of them seem to go in one general direction toward fresh fields. At the time of migration, the caterpillars are ordinarily pretty well advanced in size and require only a few days more of good feeding to be ready to change to pupae. This they do in the soil, buried only an inch or so beneath the surface. There are three generations each year, one with the larvae maturing in early spring, one in July, and one in the fall, usually in September. The midsummer generation is the one that proves troublesome in most instances, although the fall generation occasionally attacks lawns.

The eggs of the army-worm are laid in rows usually on the leaves of grasses.

The caterpillars may reach a length of two inches. There is considerable variation in color, some examples being light and others quite dark. The eyes are yellowish, marked with a net-work of brown, and the body is striped longitudinally with yellowish and brown, often with some red in the lighter portions. The naked pupae are about three-fourths of an inch long and brown in color, while the adult moth or "miller" is of a general clay color, and measures something less than two inches across the extended wings.

The adults may be found in small numbers at almost any time in the summer, if one searches carefully at electric lights, but at certain seasons their numbers are greatly augmented.

As is the case with many other pests, the army-worm is normally kept in check by its parasites. Chief among these is a Tachina-fly, the white, china-like eggs of which are often to be seen glued to the sides of the necks of the caterpillars, and notably when they are in force sufficient to do injury. The maggots from these flies live inside the living bodies of the army-worms and eventually cause their deaths. When from weather conditions or some other cause the parasites fail to keep the pest down, an invasion is the result.

REMEDIAL MEASURES.

When the worms once get into a piece of ground in force, there is little hope of saving the crop on that particular piece, but it is quite possible to keep the "worms" out of new fields, or new parts of the same field, simply by the use of the plow. Turn two or three furrows, spaced three or four feet apart and turned toward the advancing worms. This will commonly stop them. Army-worms are not good climbers and if the land-side of the furrow be straightened up wherever it breaks down, the "worms" will be confined and simply follow along the bottom of the furrow, until they find a rough place or an over-hanging weed or other

object on which they can climb. When the furrow becomes partially filled, it is necessary only to turn it under and allow the "worms" to collect in the new furrow.

Sometimes the character of the soil does not render it possible to turn a clear, smooth furrow, and in such cases it is often expedient to drag a small log or large post lengthwise through a deep furrow, crush in the "worms" as they accumulate.

GRASSHOPPERS.

(*Melanoplus atlanis, M. femur-rubrum, Camnula pellucida.*)*

Of the many forms of grasshoppers known in the United States, Michigan has less than half a dozen of real economic importance, and of these we may consider three as pests. They are, the lesser migratory locust, the red-legged locust, and the pellucid locust. Of these, the first two look very much alike, and as far as their appearance goes, they may be treated as one. They are both dull olive-green in general color, with an oblique yellow stripe under the wings. The hind-legs are red. The species look so much alike that it is an almost hopeless task for the farmer to distinguish between them; their habits however, are not quite the same. Grasshopper outbreaks, in our state, are quite likely to be due to large numbers of the lesser migratory species, rather than of the red-legged locust. The pelluid locust is smaller than the other two, and brown in color. The wing-covers have the basal half brown, and the apical half translucent except for spots of brown. In our state the pellucid and lesser migratory locusts sometimes work together, the most serious of the Michigan outbreaks being brought about in this way.

The life-history of our native hoppers is quite simple. There is but one generation each year, the young coming out in May or June. When first out of the eggs, the little creatures are so small that they easily escape detection, but as time goes on, and they become larger, they require so much food that their work becomes noticeable. When full-grown, the grasshoppers lay their eggs in pods in the soil, selecting dry situations in sod where possible. They like old slashings, lanes, etc. The eggs are laid in pods of twenty or thirty, each pod being coated with a thin covering of brittle material which consists of dried mucus ejected with the eggs. This covering is waterproof. It is replaced at the upper end by a plug of frothy material through which the young can make their way in the spring. The egg pods are placed in the soil or among the grass roots, never more deeply than the length of the mother's abdomen.

REMEDIES.

Three methods of combating grasshoppers are feasible in Michigan, each being suited to its own conditions. Other methods are practical elsewhere but do not seem to commend themselves in our state.

* Revised from Bulletin 233, "Insects of the Garden."

Fall plowing.—This is most efficient where it is possible at all. Plow the egg-pods under, burying some, and breaking open others so that moisture can get in, and exposing still others to the attacks of their enemies,—birds, shrews, etc.

Poisoned baits.—The second method is that of poisoned baits. Use either poisoned bran or the Criddle mixture. Poisoned bran can be used only in situations where stock and poultry are excluded. Neither should it be used where partridge and quail are likely to feed. It is merely bran poisoned with paris-green or arsenic, two pounds of paris-green to 100 of bran, moistened with water and a little molasses, so that the bran will just stick together when taken up with a spoon.

Criddle mixture is horse-manure mixed with arsenic and slightly salted. It is to be distributed about the fields in small masses. We all know of the fondness of grasshoppers for anything containing salt. They will even roughen fork handles in their efforts to get at the salt deposited on them with the perspiration. This mixture is recommended in Canada and in some of the western states. The proportions are about as follows: Paris-green, one pound; salt, two pounds; fresh horse-droppings, 100 pounds. The horse-droppings are usually measured out in a three-gallon pail. Five pailfulls being taken as the right amount for one pound of the poison. The salt is dissolved in a pail of water, the poison stirred in, and the whole mixed with the droppings in a half barrel.

Hopperdozers.—A hopperdozer is a long, shallow pan of sheet-iron, set on runners and having behind it a banner or sail made of canvas or muslin stretched on a wooden frame. The bottom of the pan is covered with rags or old carpet, previously wetted with water. When all is ready, a pint of kerosene is poured over the wet rags, and the banner of cloth is also moistened with kerosene. The dozer is then dragged on its runners over the field and the hoppers either jump in or try to jump over, in which case they strike the banner and fall back into the oil. A mere touch of the oil is certain death; it may take half a minute if the insect falls directly into it, or it may take half an hour if the insect simply alights on the banner moistened with the oil, but no matter whether the insect dies immediately or takes a little time, it is sure to die eventually. The great majority of the hoppers that jump into the pan, jump out again at once but they die just as certainly and almost as quickly as if they remained.

Fig. 32.—Red-legged locust. (After Riley.)

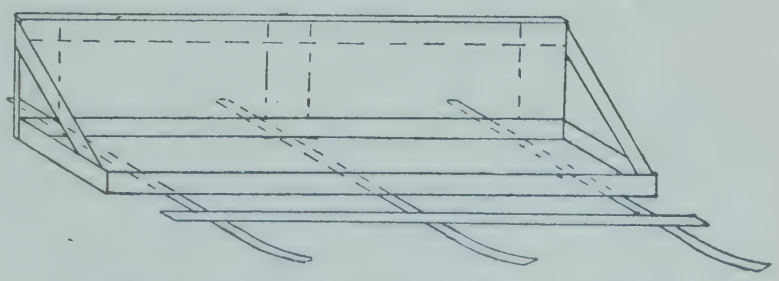


Fig. 33.—Hopperdozer. (Author's illustration.)

THE GRASS THRIPS.

(*Anaphothrips striatus.*)

Early in June of 1907, the oats over a large part of Michigan commenced to turn yellow or reddish and to assume a most unhealthy appearance. An examination revealed the presence of many minute and slender insects, about one-twentieth of an inch in length. An idea of the appearance of the insect under a fairly strong glass is shown in figs. 34 and 35.

The colors are as follows: Thorax buff with dark-brown markings; abdomen buff with broad dorsal stripe, often ill-defined, bordered laterally with narrow, yellow stripes; legs and abdomen buffy, tinged with yellow; under surface almost egg-yellow; wings smoky; eyes purple, three ocelli orange; antennae buff at base, shading to brown at tip.

The effect on the plant is more noticeably marked if it is attacked before the head forms, and when the leaves are still unfolding. The

Fig. 34.—Adult grass thrips, greatly enlarged. (Author's illustration.)

Fig. 35. Immature grass thrips, greatly enlarged. (Author's illustration.)

young leaves, which are unrolling, are tender and furnish a retreat for the little creatures, where they scrape off the epidermis and feed on the scrapings and on the sap which exudes. Scars from the scrapings show after the leaves become completely unrolled, at which time they discolor and show as blackened lines lengthwise of the leaves. Oats which are advanced and which have headed out show less injury, because the leaves are then completely unrolled and toughened. Besides oats, the thrips is found on corn, but here the injury is less marked, resulting in discoloration but seldom sufficient to prevent the production of a crop.

Oats badly attacked may fail entirely or they may produce a fair crop, depending on their age and condition at the time of attack, as well as on the time of duration of the difficulty.

Thrips thrive best in hot, dry weather. Moisture usually stops their depredations and it is only when a late spring is followed by a hot dry spell that Michigan has suffered any serious losses from the thrips on oats.

The only preventive measure which the writer is able to suggest is clean culture, and the destruction of rubbish all over the farm.

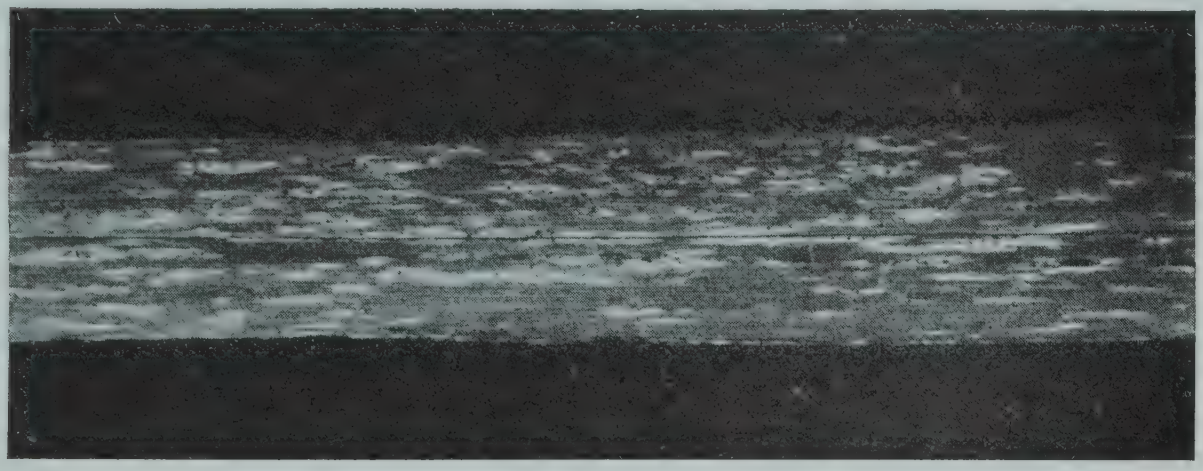


Fig. 36.—Work of thrips on oats, enlarged. (Author's illustration.)

INSECTS AFFECTING FIELD PEAS.

WORKING IN THE SEED.

PEA-WEEVIL.

(*Bruchus pisorum.*)

The pea-weevil differs quite markedly from the bean-weevil, being larger and only one working in a single pea. But most important of all is that it does not continue to breed in dried peas after they are stored away. Only one generation develops each year since the eggs are always laid on the growing pods of the host plant. Many of the beetles remain in the seed, in this latitude, until planted in the spring. This is quite commonly the case if the seed is stored in a cool place. If the seed is stored where it is warm, the beetles are more apt to emerge during the winter when many of them die off before spring.

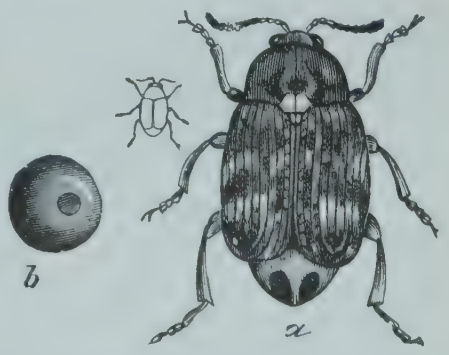


Fig. 37.—Pea-weevil. (From Bureau of Ent. U. S. Dept. of Agr.)

REMEDIES.

Storing the seed in a warm place during winter, thus leading the beetle to emerge and die off, is quite generally practiced on a small scale.

Holding over the seed for one season in tight bins or sacks will free the seed of all pea-weevil, and fumigation with carbon disulphide during a warm spell in the winter will clean the seed, when neither of the first named measures are expedient.

BEAN WEEVIL.

See insects affecting the bean.

INSECTS AFFECTING POTATOES.

See Bul. 233 Mich. Agr. Exp. Sta., p. 42-46.

INSECTS AFFECTING TIMOTHY.

WORKING ON THE ROOTS.

CORN AND TIMOTHY BILL-BUG.

(*Sphenophorus sculptilis.*)

See insects affecting corn.

WHITE GRUBS.

See insects affecting corn.

WIRE WORM.

See insects affecting corn.

WORKING ON STALKS.

CUT WORMS.

See insects affecting corn.

WORKING ON LEAVES.

GRASSHOPPERS.

See insects affecting oats.

GRASS THRIPS.

(*Anaphothrips striatus.*)

Besides oats, this tiny insect works on timothy and other grasses, attacking the central stalk just above the top node and causing it to wither. It thus cuts off the supply of food to the head and the latter dies and turns white, giving rise to the common term of white heads or silver-top. It sometimes kills in this way a large proportion of the grass crop in limited areas.

For further discussion of the Grass-thrips, see "Insects affecting Oats."

INSECTS AFFECTING WHEAT.

INSECTS WORKING ON THE ROOTS.

WHEAT WIRE-WORM.

See insects affecting corn.

WORKING ON THE STRAW.

THE HESSIAN-FLY.

(*Mayetiola destructor.*)

Probably the worst enemy of wheat in Michigan is the "fly" or Hessian-fly, so named because it is believed that the pest was introduced into this country by the Hessians in straw, during the Revolutionary War. The insect produces several generations each year, of which two are well defined. A knowledge of these two generations is of prime importance to raisers of wheat. To start with the fall generation, the egg is laid on the upper surface of the young plants of fall wheat. It is nicely placed lengthwise between two of the ridges on the leaf surface and is slender and pointed, nearly colorless at first but turns reddish later. After a short time the young maggot from the hatched egg works its way downward to the main stalk and, following the course already started, disappears downward inside the leaf sheath or, in other words, between the sheath and what is to become the main stalk. Here it feeds on juices which it causes to exude, and gradually attains a size of about 3-20 of an inch. At this time the maggot forms a new skin inside the outer one, just as if it were going to molt, but instead of shedding the old outer covering, the maggot merely shrinks away from it, remaining inside and the outer covering turns dark brown or almost black. This black object is spoken of as the flax-seed, because

Fig. 38.—Hessian-fly. (After Packard, Third Rep. of Ent. Com., Div. of Ent. U. S. Dept of Agr.)

of its fancied resemblance to such seeds in size and color. These "flaxseeds" remain packed tightly away inside the leaf sheath somewhat below the level of the soil, often as many as a dozen being found together in a single plant. Occasionally many more are crowded into one wheat plant. The injury of course is severe in proportion to the number of flaxseeds, other things being equal. It shows in the fall, as described by Dr. Marlatt* in the darkening of the entire plant, and strangely enough in a more robust and shortened habit of growth. Later the plant is likely to show its injury in a different way. This appearance in affected plants is easy to see after one becomes familiar with it.

Fig. 39.—Hessian-fly. Flax seeds in young wheat, enlarged. (Original.)

Inside the flaxseed envelope the larva or maggot passes the winter. In the spring it changes to a pupa and later to a tiny winged fly, which crawls up inside the leaf-sheath and occupies its time in getting another generation properly started on the young wheat plants. This is done in much the same way as was the fall generation, except that instead of working underground, the maggots for the most part crawl inside the leaf sheath just above the first joint. Here they grow and pass into the flaxseed stage just before harvest, about the time that the grain is in the milk, when many of the infested plants are apt to lodge. The packing away of objects as large as the flaxseeds next to the straw is almost sure to result in denting the straw, causing it to buckle inward and thus reduce its strength materially, so that it lodges. Whether the straw buckles or not, the wheat berries are apt to be poorly filled out and shrunken, so that losses more or less severe result.

Wheat may appear to be in first class condition until two or three weeks before harvest, when it commences to show effects of the strain put on the plants. Of course, an examination would reveal the larvae or the flaxseeds under the leaf sheaths, even if the field as a whole appeared healthy.

*Circular 12, second series, Div. of Ent., U. S. Dept. Agriculture.

NATURAL ENEMIES.

Normally the Hessian-fly is kept in a more or less complete state of subjection by internal parasites, belonging to the genus *Polygnotus*, tiny little creatures, much smaller than the "fly." For a period of years the parasites will search out the immature flies, laying eggs in their bodies and allowing only an insignificant few to reach maturity, but at last, either because the parasites become starved out owing to lack of food, or because of unfavorable weather conditions, the flies multiply to such an extent that they get out of control, and it takes several years for the parasites to once more gain the ascendency. At such times we have an attack of the "fly," and it becomes profitable to aid nature in restoring the equilibrium by practices unfavorable to the fly. Once the fly gets a start it takes several years for its parasites to gain control, and once reduced to small numbers, it takes two or three years to multiply to destructive numbers. The result is a succession of waves of prevalence.

REMEDIES.

A good many years ago it was discovered that late sown fall wheat in a broad way and in the long run stood a better chance of success than that which was sown earlier. Exceptions to this rule occur and very much depends on the weather conditions. If the sowing of the wheat can be delayed so that it will not become attractive to the flies until after the main crop of flies has come and gone, it is apt to escape with a minimum of injury. The difficulty in getting the full advantage of this knowledge comes in foretelling the weather. If there were such a thing as an average season in Michigan, we could set a date which would be fairly successful in the long run. The best one can do is to delay sowing wheat during Hessian-fly years just as late as one dare risk, to get a good growth which will not winter-kill. Many of our Michigan growers have for years set the 20th of September as a good average date and sometimes this is too late, sometimes too early. It is perhaps as good a date as another. We should remember, however, that one takes chances in raising wheat during Hessian-fly years anyway, and a field, if sown too early, under such conditions is apt to be lost by reason of the fly even if it does not winter-kill.

Plowing immediately after harvest, buries the flaxseeds present, and where the field is not seeded with clover, is useful, if parasites are not present in goodly numbers. The parasites emerge through round holes cut through the leaf sheath, while the "fly" crawls out inside the sheath. Burning the stubble is directed toward the same end, but is not feasible when seeded to clover.

Trap strips,—It used to be customary to leave strips of early sown wheat around a field, which strips were to be plowed late in the fall if attacked. This practice has fallen largely into disuse in Michigan.

Destruction of volunteer wheat is good practice, as many flies manage to live over in such wheat.

The Hessian-fly is very often confused with the wheat joint-worm, and as the same methods of control do not apply to both of these pests, it is well to be sure which, if either, is present.

WHEAT JOINT-WORM.

(*Isosoma tritici.*)

As long ago as 1884, Professor A. J. Cook, then of this station, records serious losses in Michigan wheat by the joint-worm. Unlike the Hessian-fly, the joint-worm works in the walls of the straw itself, instead of between the straw and leaf-sheath.

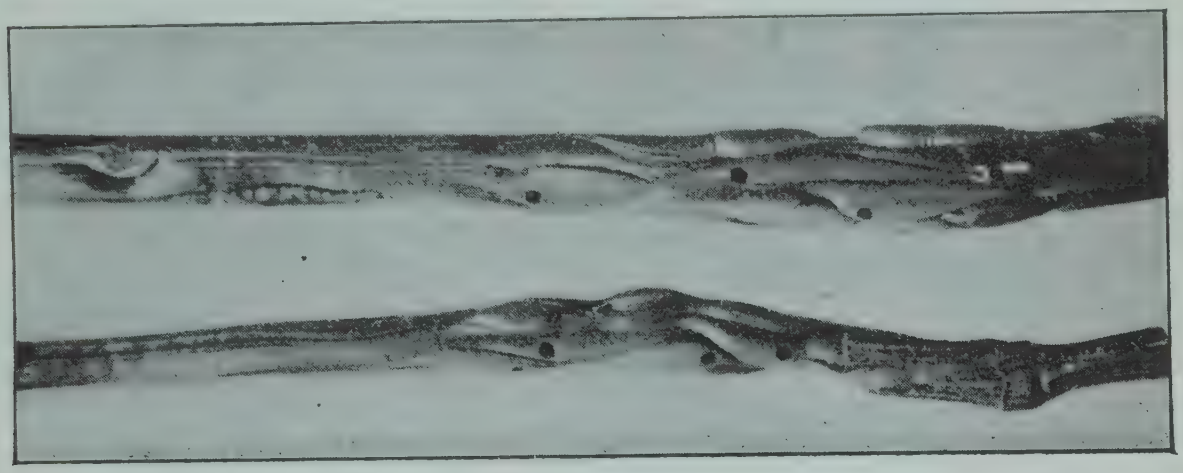


Fig. 40.—Swellings made by wheat joint-worms in straw, enlarged (Author's illustration.)

Fig. 41.—Wheat joint-worm. Sections of straw broken out by thresher; natural size. (Author's illustration.)

The work of the joint-worm is just above the joints, but it may be above any joint from the bottom to the top of the plant. This burrowing of the young larvae into the walls of the stem causes swellings and a thickening of the straw in their near vicinity. The straw becomes woody and brittle, and short pieces of tough, wood-like straw break out during threshing. The thickening of course interferes with the proper

Fig. 42.—Wheat joint-worm, much enlarged. (After Maraltt, Farmers' Bulletin 132, Bureau of Ent. U. S. Dept. of Agr.)

filling out of the heads and of the berries. As a result the yield is often cut down very materially. Fig. 40 shows the characteristic work of the joint-worm, the swellings showing over the cavities which have contained larvae. Each cell has contained a tiny grub or larva, which later changed to a pupa and after that to an adult, a black-winged, wasp-like creature of very small size, about three-sixteenths of an inch or less in length. The female adult pierces the straw and lays the eggs for the next crop. One brood each year is the rule, the eggs being laid in the spring in young and tender plants and the winter being passed in the cells in the straw in stubble, and in the mow and stack.

None of the score or more varieties of wheat which we have examined seem to show any degree of immunity.

Often the first time that a farmer suspects anything wrong is when his wheat turns out to be shrivelled after threshing. He usually blames the Hessian-fly, but he may notice quantities of short pieces of woody

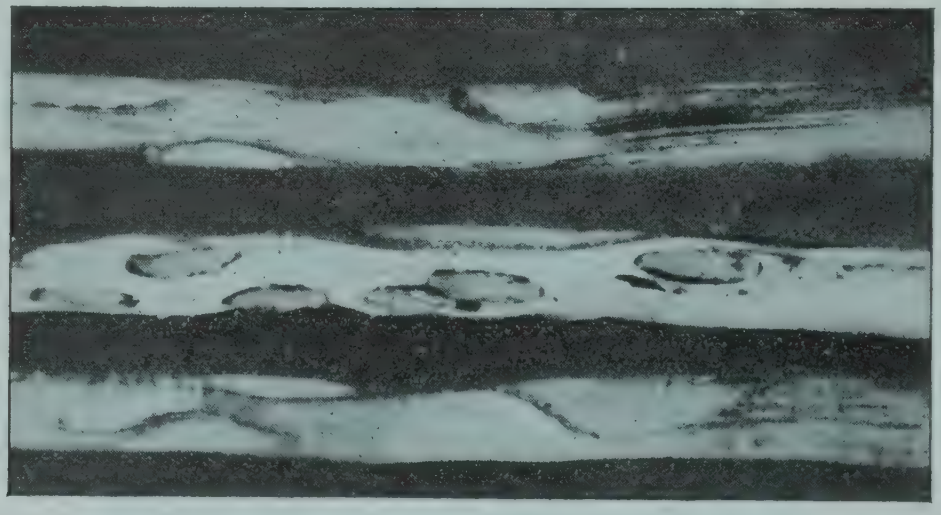


Fig. 43.—Wheat joint-worm. Pupa in straw, enlarged. (Author's illustration.)

straw that come from the separator, and this may cause him to question the matter further. These short pieces are quite characteristic, and when once seen and understood, point at once to the cause of the trouble. the writer at first believed that these pieces, being full of larvae or pupae, were an important means of keeping the pest over until the following spring. Experiments were therefore tried for two successive years to determine the best way of killing the larvae without destroying the straw. The short pieces were treated in various ways and placed in cages alongside of untreated pieces. Strange as it may seem, almost no adults came from either the treated or untreated sections, although straw from the stubble yielded quantities of adults. Professor Webster has noted this same phenomenon, and suggests wisely that the shock

of the separator is to blame for killing the inmates of the short pieces, at least.

REMEDIES.

Probably most of the pests winter in stubble. For this reason, when the pest is present in numbers, place new wheat fields at a distance from old ones. If, by any chance, the field is not seeded with clover, plow immediately after harvest.

Bad cases of infestation have followed top dressing in the fall with fresh barnyard manure and straw. As this is not a common practice, it is hardly worth while to warn against it.

Sow the wheat in time to get a good stand. Strong plants stand the strain best.

Be sure to distinguish between the joint-worm and the Hessian-fly, for the treatment of the two pests is not identical, by any means. If in doubt, send a specimen to the Entomologist of the Experiment Station.

WHEAT SAW-FLIES.

Several saw-flies are known to work in wheat in the states near us, *Dolerus arvensis, Pachynematus extensicornis* and *Cephus pygmaeus,* the first two named feeding on the leaves or cutting off the heads of wheat, and the last named living inside the straw and cutting it partially or entirely off. The first named, *Dolerus arvensis*, is quite common in the adult state, but we have not thus far seen any serious injury done in Michigan by any of these saw-flies.

WHEAT-STEM MAGGOT.

(*Meromyza americana.*)

From time to time one sees white-bleached heads scattered through a field of green wheat. An examination of such plants in many cases shows the straw to be dead above the top joint and the lower part of the top section of straw to be shrivelled. Sometimes one is lucky enough to find a larva or maggot about one-fourth of an inch in length, inside the leaf sheath, working there and revealing the cause of the death of the heads. This form of trouble is found also in barley, oats, rye, and several other grasses, in fact the worst case ever seen by the writer was in rye.

There appear to be three generations each year. One generation passes the fall, winter and spring in the young plants; one generation in the late spring and early summer in the same fields but older plants; and one generation is said to develop after harvest in volunteer wheat. The insect is common enough in Michigan at times. We have not thus far, seen very serious results from it, though it appears scattered in green-headed fields and is easily bred from small wheat plants taken up in spring or fall. The adult fly is about one-fifth of an inch in length and striped longitudinally.

REMEDIES.

As this insect lives on several grains and grasses, rotation loses much of its force. The main practice on which we can count is that recommended by Professor Webster, viz. threshing as soon as possible and stacking the straw so as to hinder those inside from coming out. The

immediate destruction of the straw would kill many, but the loss of the straw would probably prove more than that from the maggot, at least in all cases yet seen in Michigan by the writer.

Fig. 44.—Wheat-head fly, and its work. The lower left-hand figure is a parasite. (After Lugger.)

WORKING IN THE HEAD.

GRAIN APHIS.

(*Siphonophora avenae.*)

Probably the most misleading insect on the grains, if not on the farm, is the common northern grain-aphis. It collects during some seasons in great numbers on the heads of wheat, rye, barley, and oats; sorghum and other near relatives of the grass family, sometimes fairly packing full the spaces in the heads of these plants, and seeming to threaten their very existence. This gathering in great numbers usually occurs just as the grain is in the milk. In all the instances seen by the writer, the threatened injury has been averted by tiny parasites which have destroyed the plant-lice and reduced the loss to a nominal one.

Fig. 45.—Northern grain-aphis, winged female, greatly enlarged. (Author's illustration.)

The northern grain-aphis appears very much like other plant-lice, both winged and wingless forms being found. The color is green with black markings. Fig. 45 gives an idea of its appearance under a strong lens. Before the grain commences to ripen, the parasites usually commence to destroy the lice. These parasites are black for the most part, and about one-tenth of an inch in length. They move about with a quick, nervous motion. They lay their eggs in the living bodies of the lice. The grubs or larvae from the eggs feed on the body contents of the living lice, and when full grown each spins a cocoon inside the skin of the dead louse, swelling it to a pear shape, and changing the color to a brown or copper tint. Fig. 47. After pupation occurs inside this cocoon, the parasite cuts out a neat circular door in the skin of the louse in order to get out.

Fig. 46.—*Lysiphlebus*, parasite of grain aphis, greatly enlarged. (Author's illustration)

The multiplication of the plant lice is rapid indeed, but that of the parasites is still more rapid, so that before the grain is killed the lice are for the most part destroyed. Of course this may not always occur, but so far the writer's experience with them has been that their bark is far worse than their bite.

In contrast to their work is that of the southern grain-aphis, or the green-bug.

SPRING GRAIN-APHIS,

OR GREEN-BUG.

(*Toxoptera graminum.*)

The green bug, which has attracted so much unfavorable comment in the South during the last year or so, has been found once or twice in Michigan* in very small numbers. Careful search has been made in various parts of the state, but, thus far, only a very few examples have been found. It is, however, an insect with which we are likely to have to deal sooner or later, hence this brief account, which the writer has been obliged to draw altogether from information furnished by Professor F. M. Webster of the National Bureau of Entomology. His circular 93, revised, of the National Bureau of Entomology, of 23 June, 1909, gives a very complete account of the pest up to date.

The green fly is a green plant-louse introduced from Europe. It is especially destructive to wheat, oats, barley and rye, but works also on a number of wild and cultivated grasses and on corn.

Fig. 48.—Spring grain-aphis, enlarged. (After Washburn.)

Now this plant-louse is present over its range all of the time, but normally in small numbers. It exists in both winged and wingless forms, and the former migrate freely, spreading the trouble rapidly over wide areas.

The winged forms are to be distinguished from those of the Northern grain-aphis by the manner in which the veins are disposed in the wings, the northern species having one more fork than the southern. The creature is normally kept in control by its parasites, the most effective one of which belongs to the genus *Lysiphlebus,* somewhat similar to the one working in the northern grain-aphis. The effectiveness of the work of this little friend depends primarily on the "weather intervening between November and May."

Professor Webster relates finding these little plant-lice breeding in the fields, in Indiana during an open winter, when the temperature was

* In August, 1908, at Adrian, Lansing and Reed City, on blue grass, by Mr. Phillips of the Bureau of Entomology; in Litt., from Prof. F. M. Webster.

below freezing. It seems to be the usual thing for these aphids to breed right along when the temperature is 46° Fahr., during weather when most other species either become inactive or else die. Their parasite, *Lysiphlebus,* on the other hand, requires a much higher temperature for successful development, at least above 56 degrees Fahr. A cold, backward spring, therefore, will hold back the parasites and still not retard the aphids to any extent. This type of spring, when preceeded by an open winter, furnishes ideal conditions for the aphids, and it is in such seasons that severe invasions occur.

The range of the green bug is given by Professor Webster as follows: From New Mexico, Colorado, and Montana to the Atlantic coast, approximately covering the area south of latitude 41 degrees, excepting New York, New Jersey, and New England, and east of longitude 105 degrees. Professor Webster states that best-farmed fields suffer the least. When the trouble starts from small deadening spots, these spots may be plowed under or harrowed and rolled, or straw may be spread over the spots and burned, or they may be thoroughly sprayed with a one to ten dilution of kerosene-emulsion. This is said to apply more particularly in the South, when the spread from restricted spots is more often noticed.

WHEAT MIDGE.

(*Contarinia tritici.*)

An occasional enemy of wheat is the "midge" or, as it is sometimes erroneously called, the "red weevil." It is not a weevil in any sense, but it works in the flower and on the developing berry. It is a tiny pink maggot, and when present in sufficient numbers, may give to the entire head a reddish tinge. This accounts for part of the name. The adults of the "midge" are minute, yellowish flies, not more than one-eighth of an inch in length. Their eggs are laid on the glumes or chaffy envelopes of the flowers, and the maggots work down into the region about the forming seed, when part of the juice of the young kernel is made to exude by the irritation set up by the presence of the maggots. This results in the shrivelling and deforming of the seeds when they ripen. The heads are apt to be poorly filled as well, resulting in a crop that is disappointing. There is usually but one generation each year, although

Fig. 49.—Wheat midge greatly enlarged from photo, 26 July. (Author's illustration.)

there is reason to suspect the presence of a partial second crop of adults, at least. Beside wheat the "midge" is said also to work on rye, barley and oats.

When full size is attained by the maggots, they descend to the ground, often being washed down by rains, and here they spin very minute cocoons in which the pupal stage is passed. During June of the following year, the flies come forth and lay their eggs. Wet weather and warmth favor their increase, while cold, dry weather proves unfavorable.

Fig. 50 —Wheat-midge, greatly enlarged 27 Nov (Author's illustration.)

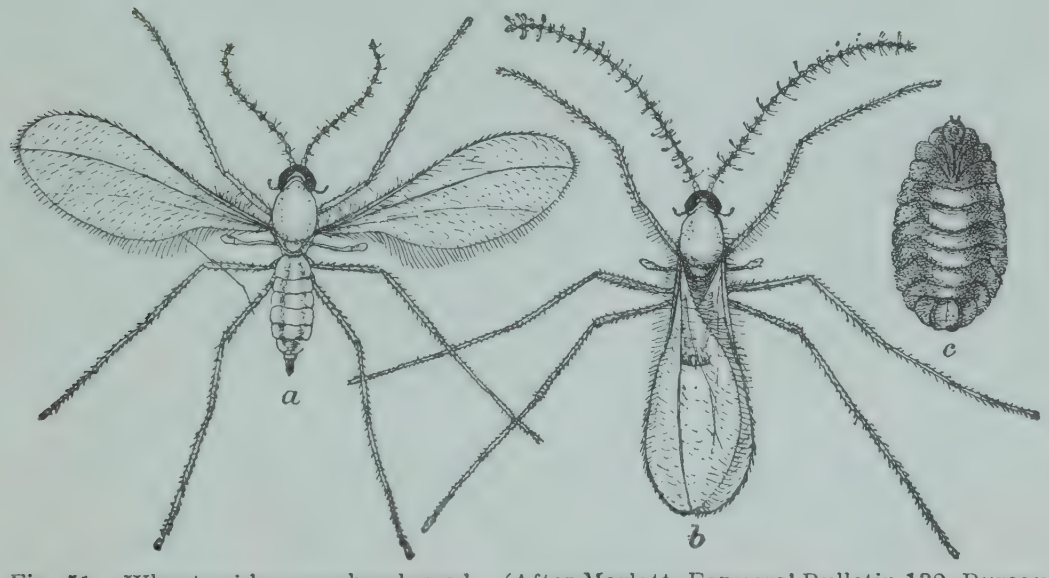


Fig. 51.—Wheat-midge, much enlarged. (After Marlatt, Farmers' Bulletin 132, Bureau of Ent., U. S. Dept. of Agr.)

REMEDIES.

Deep plowing of the stubble after harvest buries the larvae and kills a large proportion of them. The larvae and pupae are, however, very tenacious of life. Many fail to descend to the ground in time and are carried to the barn with the chaff. For this reason all chaff should be burned after an invasion.

There is a feeling, quite prevalent among wheat growers that the early varieties escape with less injury than do those maturing later.

TREATMENT FOR INSECTS IN STORED GRAINS AND SEEDS.

The treatment for dried grains containing insects is comparatively easy, providing the grain or seed is in tight bins or barrels, capable of being tightly and quickly closed. Old carpets, blankets, etc., often will be found useful in helping to make the bins tight.

Measure the inside of the bin, counting in the air space above the grain, if the bin is not entirely full, and place some old pans or plates on top of the grain. Then for every cubic foot of space in the bin, put a dram of liquid carbon bisulphide in the pans and quickly close the bin. Thus a pound of the liquid will suffice for about one hundred cubic feet of space or a little more, or for about one hundred bushels of grain. This treatment is far more effective during warm weather than in cold. During severe cold weather the insects are dormant and resist the action of the fumes quite successfully.

If the seed or grain is more than two or three feet deep in the bin, the liquid should be poured into it at some depth in order to insure its spreading evenly and filling all the space treated. This is easily done with a piece of gas-pipe fitted with a wooden stick for its entire length. The pipe with the stick in place is thrust down half way to the bottom of the bin, the stick withdrawn and the liquid poured down through the pipe. The stick merely prevents the pipe from becoming filled when thrust into place. The bin should remain tightly closed for from twenty-four to forty-eight hours, a longer exposure is likely to injure the germinative power in some seeds.

The liquid carbon bisulphide, on being liberated, will be quickly transformed into a gas, which being heavier than the air, settles to the bottom and fills all the air spaces between the seeds or kernels. The liquid costs about thirty cents for a single pound, or five pounds for a dollar. The work must be done in the day time, away from lamps, stoves or fire of any sort. No fire must be allowed to come near until everything has been thoroughly aired for the gas or fumes are very explosive when mixed with air. Grain should be shoveled over several times. Great care must be observed to breathe as little as possible of the fumes as they are very poisonous and will as easily produce death among men as among insects.

FOREWORD.

Bulletin No. 259.

This publication has been prepared for the specific purpose of furnishing information relating to the ordinary cultural methods employed in growing the field bean under Michigan conditions. The bean crop occupies an important place among the crops of the state, and the state occupies first place among the bean producing states of the Union. There has been an extensive demand for information bearing on this subject and up to this time the Experiment Station has not had any published material with which to meet the demand. The Experiment Station has been carrying on investigations relative to certain phases of bean production, chiefly features relating to diseases and their control. Our object, at this time, is to offer a plain, practical statement relative to the suitability, preparation and fertilization of soils; varieties; harvesting; marketing; threshing; etc.; and later to furnish material reporting results of experiments not yet completed.

R. S. SHAW,
Director.

BEAN GROWING.

BY W. F. RAVEN.

The bean crop is not universally grown throughout this country. The states producing more than 50,000 bushels of beans each year according to the Twelfth Census Report are Michigan, New York, California, Florida, Wisconsin, Maine, Virginia and West Virginia. Michigan, New York and California produce over sixty per cent of all the beans grown in the United States.

VARIETIES.

The field beans most widely grown in Michigan, and probably the most popular commercially, belong to the pea group. The following names are commonly, though perhaps not properly, applied to the varieties grown; viz.: Pea, navy, white navy, white field, marrow pea bean, etc. Despite the variations in name, the types are practically identical.

The five leading varieties of beans grown in Michigan are the pea, medium, red kidney, white kidney and black turtle-soup. A great number of varieties of garden sorts are grown in the state by farmers to be used by seedsmen in the retail trade. The varieties in the pea group will in most cases outyield the other sorts and are the most profitable to grow. After fifteen years' experience in growing beans the Hon. A. B. Cook of Owosso, Michigan, says, "I have come to the conclusion that as a money crop, one year with another, the little old fashioned pea bean has the advantage. It is hardy, early maturing, is always in demand and is the safest to tie to."

PLACE IN ROTATION.

Beans should be grown in the regular rotation of farm crops and preferably on over-turned clover sod. The following is a good three-year rotation, viz.: First year, beans, corn or potatoes; second, wheat or rye seeded to clover, and third, clover. If some alsike clover and timothy are mixed with the clover seeding, the hay crop may be followed by pasture, thus extending the rotation to four years if necessary. While this rotation is well suited to Michigan conditions, it can, of course, be varied to meet special requirements. The smaller varieties of beans mature most quickly thus giving opportunity for the preparation for wheat or rye to follow.

SOIL.

While clay loams or soils overlying limestone are most desirable, sandy and even gravelly loams may be used, but these latter soils should contain more or less humus and the gravelly soil should not be too coarse. Beans may be grown on heavy clay soils but the surface or underground drainage, or both, must be good and special attention must also be given cultural methods to produce a fine, mellow seed bed. Muck soils or those with a superabundance of humus are not suitable as they tend to produce vines at the expense of the seed. It is also true that this crop will not thrive on low, wet, poorly drained soils. Beans seem to produce good crops on soils somewhat deficient in nitrogen when well supplied with potash and phosphorus. Contrary to a somewhat prevalent notion, beans will not produce well on very poor soils, but require a fair degree of fertility.

PREPARATION OF THE SOIL.

It is essential that the plowing be done early in the spring, but, owing to the lateness of the dates of seeding, this is frequently neglected till the latter part of May, much to the detriment of the crop. After plowing, the land should receive frequent cultivation to bring it to the best possible condition of tilth. These methods are productive of three principal benefits, viz.: First, plant foods are more readily available when the crop is sown; second, moisture is conserved for the needs later in the season; and third, the soil is in a large measure freed of weeds, before sowing, which would otherwise interfere with the crop.

FERTILIZERS.

In growing beans on light, sandy soils or others lacking in fertility, it will be found profitable to top-dress with fine or well rotted stable manure after plowing. If a manure spreader is used, from six to eight loads per acre will be sufficient. If applied by hand more would be needed because of less even distribution. The stable manure may be supplemented by commercial fertilizers containing the following amounts of available plant foods per acre, viz.: From 15 to 20 lbs. muriate of potash and from 20 to 30 lbs. acid phosphate. These materials may be evenly distributed over the field by spreading them over the top of each load of manure applied by the spreader. These applications of fertilizer should be followed by the disc harrow in order to intermix the materials with the surface soil. This method tends to conserve moisture in addition to supplying plant food.

Mr. A. B. Cook recommends the following: "Commercial fertilizers of the analysis usually recommended for wheat and other grain crops; that is, two, eight and three per cents respectively of nitrogen, phosphoric acid and potash, may be used with profit to the amount of about 200 lbs. per acre. In case the ground is moist and the weather warm so as to insure a quick germination, the fertilizer should be run in the hoe which carries the beans and in one hoe on each side as well, thus using nine out of eleven hoes of the drill. If conditions are not good for germination, run the fertilizer only in hoes on each side of the

one carrying the seed. It does not do to have the bean lie long in contact with the fertilizer as the germ is affected thereby."

RATE OF SEEDING.

From one-half to three-fourths of a bushel of seed per acre of the smaller varieties of beans is sufficient. All of the large varieties, such as red kidney, require one bushel to the acre.

TIME OF PLANTING.

The time of planting varies with the season and the varieties grown from June 1st to 25th. The larger varieties such as kidney and turtle-soup may be planted earlier than the pea sorts. Too early planting of beans is to be avoided. If conditions such as cold and excessive moisture prevail, the seeds are easily spoiled before germination. Mr. Sheap, of S. M. Isbell Company, Jackson, Michigan, says, "When beans are planted in too cold or wet ground, even if a fair stand is secured, the young plants do not get an even start. The best seed will start first under these unfavorable conditions, resulting at harvest time in uneven ripening, which is always a loss to the grower." It is better to delay planting, awaiting favorable conditions for quick germination and rapid growth.

PLANTING.

One of the best machines for planting beans is the ordinary eleven-drill grain seeder with seven-inch spaces between the tubes. Stop up all the tubes except the second, sixth and tenth and let the drill wheel follow in its own outer wheel mark instead of in the last drill mark as in sowing grain. This will plant three rows at a time twenty-eight inches apart, which is about the proper distance. In planting the larger varieties of kidney beans, a bean attachment or special bean drill should be used. Some makes of grain drills have attachments for planting beans. Planting in rows will produce better yields of beans than planting in hills or check rows.

The following statement is submitted by Mr. Cook.

"One of the first requirements of a good crop of beans is a good stand and to secure this we must have a quick, even germination. To secure this it is essential that the seed be planted shallow, just deep enough to cover well in a fine, moist soil. To do this, press wheels on the hoes which are carrying the beans are a great help. They regulate the depth, press the soil slightly and assist materially in securing an even stand and evenness at maturity.

SELECTION OF SEED.

Care should be exercised in the selection of beans for seed. None but the best hand-picked beans should be used for planting, as the success of the crop is quite largely dependent on the vitality of the seed.

CULTIVATION.

Much of the cultivation work on the bean field should be done before the seed is planted by producing a good, clean seed bed. If this has not been done, and the beans come up quickly, cultivation should begin promptly. As the rootlets of the bean plant grow near the surface, they should not be cultivated too deeply, not more than one and a half inches for the best results. We believe growers suffer severe losses by too deep cultivation, especially during drouth. Most growers do not cultivate while the leaves are wet with dew or rain for fear of causing the spread of anthracnose and bacteriosis. The following is quoted from Bulletin 255, Experiment Station, Ithaca, N. Y.: "Cultivating or working beans when wet should be avoided as much as possible. On this point there can be no dispute. The character of the parasite causing the disease, and the practical experience of the growers everywhere, show that this recommendation is correct."

HARVESTING.

The time for harvesting beans depends largely upon climatic conditions, earliness of planting and varieties grown. The latter part of August and early September comprise the common harvest time. If weather conditions are favorable for quick curing, it will be well to begin harvesting before the beans are ripe enough to shell. On the other hand, if weather conditions are unfavorable, it is well to let the crop get ripe so that most of the leaves have dropped off. The crop will then cure quickly and can be stored away. The sooner the bean crop can be stacked or housed safely, the less the liability to loss by unfavorable weather.

The pulling of beans is usually done with a bean puller or harvester, replacing the old tedious, back-breaking method of pulling by hand. The bean puller pulls two rows at a time, placing them together in a row between. Care should be taken to have the draft to the puller adjusted so that the blades cut about one and a half to two inches below the surface the whole length of the puller blade. This should be adjusted with each team that is used by raising or lowering the end of the pole, so that when the blades strike the ground they will cut the whole length. Men should follow with forks and put the beans in small piles, about four to six rows into one, for convenience in hauling. The rows of piles should be far enough apart so the wagons can be driven between them. In some parts of the state the side delivery rake is used for separating the beans from the ground after being pulled. This is objectionable on all but light soils as it gets too much soil among the vines and as the threshers do not separate the soil from the beans, they go to the elevators in that condition.

Should the beans get wet after being pulled, they ought to be turned as soon as possible after the storm. The wetting of beans does not injure them materially provided they are not allowed to lie on the ground without being turned over. They should be stacked or put in sheds or barns as soon as cured.

THRESHING.

Beans are now threshed by a special machine or beaner which has been instrumental in materially increasing the acreage of beans grown. These machines are usually introduced into localities where beans are grown commercially and offered for hire on a plan similar to that used by grain threshers.

MARKETING.

The usual practice is to market beans in the condition in which they come from the beaner, leaving the cleaning, grading and picking to the elevator men. Michigan has over 200 bean elevators well equipped with the latest and best machinery for this work. Most bean elevators will furnish the grower with enough two-bushel sacks to hold his crop providing the grower will sell the crop to them. The elevator men then prepare and distribute the crop to the different markets for consumption.

DISEASES.

BEAN ANTHRACNOSE.

The following is quoted from Bulletin 255, Cornell Experiment Station, Ithaca, N. Y.:

"The bean anthracnose is known to growers under a number of different names, depending largely upon the locality. Perhaps the most common one applied to this malady is 'rust.' However, as a matter of fact the disease is not rust at all, though the spots do have a reddish yellow color in their early stages. There is a true rust of beans which is rarely met with in ordinary bean fields. Podspot is a name which is frequently applied to the disease, as it appears in the pods. Blight is also commonly used, but incorrectly so, as we have a true bacterial blight of beans, which is not only very common, but frequently quite destructive. The general characters of these three most common diseases of beans are set forth in bulletin 239, and accompanied with figures which show clearly their respective characters." "The disease is readily recognized by the appearance which it gives to the infected pods, and it is here that the trouble is usually first recognized." "The disease may and usually does occur, however, on all parts of the plant except the roots. It is caused by a fungus known to botanist as *Colleototrichum lindemuthianum* which lives as a parasite in the tissues of the bean. This fungus is a plant, as much a plant as the bean on which it lives. It has a thread-like mycelium that grows into the tissue of the bean to obtain food for its growth and development and it produces spores that serve the purpose of seeds by which it spreads to healthy beans and so reproduces itself. In fighting the anthracnose fungus, we are fighting a parasitic weed, in its habits not greatly unlike the dodder which often destroys alfalfa." "In considering the methods of combating this dis-

ease three or four possible means are presented. First, seed treatment; second, spraying; third, the planting of clean seed; fourth, selection and breeding of resistant or immune varieties."

SEED TREATMENT.

Experiments reported along the line of seed treatment have generally shown that the benefits derived are insignificant. "The fungus mycelium is embedded in the bean itself. Any poison that will penetrate sufficiently to kill the fungus will usually kill the seed." Selection by hand picking to eradicate or even partially control the disease is of no value and is therefore not to be recommended as the presence of the disease may not always be visible to the eye.

SPRAYING WITH BORDEAUX MIXTURE.

After three seasons' observations in large bean fields where the most up-to-date machinery was used, machinery particularly adapted to the bean crop, conclusions seem to be that spraying with Bordeaux mixture is both unprofitable and entirely ineffective in controlling the anthracnose.

CLEAN SEED.

Clean seed will grow clean beans. From the manner in which the fungus finds its way into the seed, it is evident that if no spots are found on the pods, none of the seed within will be diseased; that is to say, healthy pods contain healthy seed. An entirely practical method, therefore, is for the grower to select enough clean beans, when ripe, for seed the next season and thus reduce, if not eradicate, the ravages of the disease.

BEAN BLIGHT OR BACTERIOSIS.

Bean Blight[1] or bacteriosis is a disease that is common upon field, garden and lima beans. "It affects leaves, stems and pods, but particularly the leaves and pods, upon which the symptoms are also most conspicuous. It is believed the diseased seed is the source of many early infections, whereas later infections may result through wounds in any green parts. On the foliage there appear irregular water-soaked patches, which later become, during dry weather, brown and papery. The disease progresses slowly, therefore it becomes evident, as a rule, only when the pods begin to form. Control is difficult, and must concern itself largely with seed selection and crop rotation. Seed from an affected field should not be planted. It is not enough to attempt to sort out healthy seed, when some of the lot are evidently diseased, for many which show no discoloration will be penetrated by the bacteria."

[1]Duggan, B. M. Fungous Diseases of Plants, p. 119.

Michigan acreage, total yield and yield per acre of beans for ten years.*

Years.	Acreage.	Total yield.	Yield per A.
1898	155,627	1,762,944	11.33
1899	138,810	1,558,838	11.23
1900	244,577	3,011,943	13.39
1901	338,334	4,639,398	13.71
1902	287,597	2,955,810	10.28
1903	350,895	5,049,990	14.00
1904	357,913	4,652,869	13.00
1905	343,596	5,153,940	15.00
1906	368,440	5,158,160	14.00
1907	371,464	4,829,032	13.00
1908	358,462	4,301,544	12.00

The following table is a compilation by McLaughlin, Ward & Company of Jackson, Michigan, of the average Michigan price F. O. B. for choice hand picked beans for eight and three-quarters years, 1899-1907:

	1899	1900	1901	1902	1903	1904	1905	1906	1907
January	$1.03	$2.00	$2.12	$1.73	$2.32	$1.69	$1.55	$1.52	$1.24
February	1.15	2.05	1.95	1.57	2.15	1.95	1.76	1.49	1.24
March	1.15	2.00	1.81	1.51	2.20	1.90	1.77	1.42	1.26
April	1.12	2.00	1.81	1.61	2.21	1.73	1.67	1.47	1.30
May	1.05	2.05	1.78	1.73	2.23	1.74	1.58	1.52	1.72
June	1.02	2.00	1.94	1.31	2.18	1.68	1.62	1.52	1.65
July	1.00	2.00	1.95	1.88	2.16	1.60	1.65	1.47	1.55
August	1.05	2.00	2.80	1.86	1.95	1.57	1.58	1.43	1.72
September	1.20	1.75	2.34	1.81	2.28	1.59	1.58	1.35	.....
October	1.45	1.70	1.86	2.35	2.20	1.70	1.58	1.30	.....
November	1.70	1.72	1.81	2.23	1.95	1.63	1.63	1.30	.....
December	1.75	1.93	1.78	2.15	1.90	1.53	1.56	1.25	.....

The average prices paid Michigan farmers for beans, which follow, were compiled from reports sent in by the owners of elevators. There are over two hundred elevators and out of the eighty-four replies received, thirty-seven complied with the request for a list of prices paid for beans during the past ten years, or for the portion of that time when they had been buying beans.

*Reports, office Secretary of State.

Average prices paid Michigan farmers for beans.

	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908
January	$0.88	$1.71	$1.82	$1.48	$1.69	$1.82	$1.40	$1.31	$1.11	$1.69
February	.95	1.79	1.72	1.39	1.74	1.77	1.41	1.32	1.14	1.87
March	1.01	1.80	1.56	1.40	1.65	1.70	1.45	1.28	1.14	1.86
April	1.03	1.81	1.61	1.31	1.61	1.67	1.45	1.28	1.14	1.90
May	.99	1.83	1.60	1.57	1.77	1.71	1.42	1.33	1.29	2.11
June	.97	1.81	1.65	1.38	1.81	1.82	1.43	1.31	1.41	2.15
July	.93	1.79	1.67	1.52	1.79	1.85	1.45	1.29	1.36	2.07
August	.95	1.54	1.90	1.53	1.59	1.65	1.33	1.23	1.39	2.03
September	1.03	1.53	1.85	1.63	1.73	1.76	1.37	1.18	1.55	1.85
October	1.23	1.48	1.61	1.94	1.61	1.70	1.35	1.16	1.71	1.89
November	1.46	1.47	1.41	1.80	1.49	1.51	1.33	1.16	1.29	1.90
December	1.56	1.63	1.51	1.70	1.42	1.46	1.30	1.09	1.56	1.91

Average prices paid Michigan farmers for beans during the following years.

1899	1900	1901	1902	1903	1904	1905	1906	1907	1908
$1.08	$1.68	$1.66	$1.55	$1.66	$1.70	$1.39	$1.25	$1.34	$1.94

Average price paid for beans for ten years, $1.52.

Average price paid for beans during each month for ten years.

January	$1.49
February	1.51
March	1.41
April	1.48
May	1.56
June	1.57
July	1.51
August	1.51
September	1.54
October	1.57
November	1.48
December	1.51

SEEDS OF MICHIGAN WEEDS.

BY W. J. BEAL.

Bulletin No. 260.

The designer of this bulletin first had in mind something of the sort for the use of his students, not only the undergraduates, but others living on farms, or teaching in Michigan and elsewhere. Whoever grows seeds to sell, or buys seeds to sow, should be benefited by consulting the illustrations which are unsurpassed for accuracy by anything in this country. They were all made by Mr. F. H. Hillman. A hand lens costing from twenty cents to a dollar is almost indispensible in examining our seeds. The brief descriptions are necessarily made by using definite scientific terms, which are explained in a glossary at the close of the work, A few weeds are not illustrated, for the reason that the plants have ceased to produce seeds, such as the horse radish, and some of them are not conspicuously bad. Not far from half the illustrations are made from small seed-like fruits, likely to be mistaken for seeds, such as are produced by dandelions, burdocks, narrow-leaved dock, all grasses. Cuts of seeds of several clovers are inserted that students may learn to distinguished them from weeds too often mixed with them.

No apology is offered for making use of the decimal scale instead of the cumbersome antiquated English scale, which fortunately is gradually growing out of use. In the back part of the bulletin are duplicate copies of the decimal scale that any one can cut out and use for measuring.

For copies of the following figures some time ago prepared by Mr. Hillman, we are indebted to the authorities of the Agricultural College, of Reno, Nevada: 7, 11, 12, 16, 17, 23, 24, 31, 32, 34, 35, 36, 37, 39, 40, 41, 42, 44, 46, 55, 56, 58, 63, 68, 69, 71, 74, 75, 84, 86, 87, 91, 92, 95, 97, 98, 99, 108, 110, 116, 125, 130, 135, 138, 140, 144, 146, 152, 153, 158, 159, 172, 173, 174, 175, 178, 179, 181, 182, 185, 187, 189, 190, 191, 199, 203, 205, 212, 214, 215.

"A weed is any useless or troublesome plant."
"A plant out of place or growing where it is not wanted."
"Tobacco."
"A plant whose virtues have not yet been discovered."—Emerson.

Weeds everywhere; they thrive in the cornfield, they choke wheat in the field, they annoy the gardner, they thrive in the meadow, they spring up by the roadside, they encroach on the swamp, they damage the fleeces of sheep. The rapid increase in the number and variety of weeds should cause alarm.

DISADVANTAGES OF WEEDS.

1. They rob cultivated plants of nutriment.
2. They injure crops by crowding and shading.
3. They retard the work of harvesting grain by increasing the draft and by extra wear of machinery. (Bindweed, thistles, red root.)
4. They retard the drying of grain and hay.
5. They increase the labor of threshing, and make cleaning of seed difficult.
6. They damage the quality of flour, sometimes making it nearly worthless. (Allium vineale L.)
7. Most of them are of little value as food for domestic animals.
8. Some weeds injure stock by means of barbed awns. (Squirrel tail grass, wild oats, porcupine grass.)
9. Some of them injure wool and disfigure the tails of cattle, the manes and tails of horses. (Burdock, cocklebur, houndstongue.)
10. A few make "Hair balls" in the stomachs of horses. (Rabbit-foot clover, crimson clover.)
11. Some injure the quality of dairy products. (Leeks, wild onions.)
12. Penny cress, and probably others, when eaten by animals, injure the taste of meat.
13. Poison hemlock, spotted cowbane and Jamestown weed are very poisonous.
14. Many weeds interfere with a rotation of crops.
15. All weeds damage the appearance of a farm and render it less valuable. (Quack-grass, Canada thistle, plantains.)

SOME SMALL BENEFITS.

1. They are of some use in the world to induce more frequent and more thorough cultivation, which benefits crops.
2. The new arrival of a weed of first rank stimulates watchfulness. (Russian thistle.)
3. In occupying the soil after a crop has been removed they prevent the loss of fertility by shading the ground.
4. Weeds plowed under add some humus and fertility to the soil, though in a very much less degree than clover or cow peas.
5. Some of them furnish food for birds in winter.

WHAT ENABLES A PLANT TO BECOME A WEED.

1. Sometimes by producing an enormous number of weeds. (A large plant of purslane, 1,250,000 seeds; a patch of daisy fleabane, 3,000 to a square inch.)

2. In other cases by the great vitality of their seeds. Shepherd's purse, mustard, purslane, pigeon-grass, pigweeds, pepper-grass, May weed, evening primrose, smart weed, narrow-leaved dock, two chickweeds survive when buried in the soil thirty years at least, as I have found by actual test.

3. In each prickly fruit of a cocklebur there are two seeds, only one of which grows the first year, the other surviving to grow the second year.

4. Some are very succulent, and ripen seeds even when pulled. (Purslane.)

5. Often by ripening and scattering seeds before the cultivated crop is mature. (Red root, fleabane.)

6. Sometimes by ripening seeds at the time of harvesting a crop, when all are harvested together. (Chess, cockle.)

7. Some seeds are difficult to separate from seeds of the crop cultivated. (Sorrel, mustard, narrow-leaved plantain in seeds of red clover and alfalfa.)

8. Some are very small and escape notice. (Mullein, fleabane.)

9. Some plants go to seed long, before suspected, as no showy flowers announce the time of bloom. (Pigweeds.)

10. In a few cases the plants break loose from the soil when mature and become tumble-weeds. (Some pigweeds, Russian thistle.)

11. Some seeds and seed-like fruits are furnished each with a balloon, or a sail, or with grappling hooks. (Dandelion, sticktights, burdock.)

12. Some remain with the dead plant long into winter, and when torn off by the wind or by birds, drift for long distances on the snow, often from one farm to another. (Pigweeds.)

13. Some have creeping root-stocks or tubers. (Quack-grass, nut-grass.)

14. Some defend themselves with forks and bayonets. (Thistles.)

15. Most of them are disagreeable in taste or odor, so that domestic animals leave them to occupy the ground and multiply. (Jamestown weed, stink grass, milk weed.)

16. Plants with stout roots are sometimes passed over by the harrow or cultivator.

HOW ARE WEEDS INTRODUCED AND HOW ARE THEY SPREAD?

1. By live stock, carried in the hair or fleece or carried by the feet; in some instances passing alive with the excrement.
2. By unground feed-stuff purchased.
3. By adhering to the insides of sacks where they were placed with grain.
4. In barnyard manure drawn from town.
5. In the packing of trees, crockery, baled hay and straw.
6. By wagons, sleighs, threshing machines.
7. Sometimes by plows, cultivators and harrows.
8. By railway trains passing through or near a farm.
9. By ballast of boats at wharves.
10. By wool-waste at factories.
11. By birds, squirrels, and mice.
12. By water of brooks, rivers, by washing rains and by irrigating ditches.
13. By the wind aided by little wings or down, or by drifting on the snow.
14. By dropping seeds to the ground from extending branches and repeating the process.
15. By creeping root-stocks, as June grass, quack-grass and toad-flax.
16. By piercing potatoes, carrots, etc., quack-grass, June grass, Bermuda grass are sometimes carried to other fields or farms where the tubers and roots are planted.
17. A farmer buys clover seeds or grass seeds that were grown in some state that never before grew seeds that went onto his farm and thus he may get some new weeds. Seeds of alfalfa or some other crop bring new kinds of weeds, especially those of dodder. As every kind of weed goes onto a farm to stay there it follows that as a country becomes older the greater the number of kinds of weeds. As a rule each farm is annually getting more sorts of weeds, and as each farmer is cultivating weeds, they are more freely distributed in every field and along every roadside and by exchanging they are carried to neighboring and distant farms.

A great many farmers buy and sow whatever the merchant offers them under the name mentioned. For example, the college has a sample of something called clover seed, sold by a dealer in this state. It contains about 40 per cent of narrow-leaved plantain.

WHERE CERTAIN WEEDS ARE TROUBLESOME.

To begin with, years and years ago no new farm in the wilderness of Michigan contained more than twenty to thirty-five kinds of weeds, as there were not more than thirty-five sorts in the entire state, while at present there are not far from 250 kinds. A large majority of weeds hail from older countries, more especially from Europe.

There are a few weeds, like Canada thistle and quack-grass, that may infest any crop of farm or garden, but in most cases, whether to call a weed very bad depends on the nature of the crop grown, the size of the weed-seeds and their time of ripening.

Some weeds have a very wide distribution, thriving all around the world in temperate climates, while others are more limited in range; some thrive only in dry, thin, sandy soil and others in wet soils. To some extent the presence of a few weed-seeds is almost as objectionable when once on the farm, as though there were more, because these few may thrive and seed freely.

In many respects the lists of weeds for New Jersey is different from the list in Michigan, while half the weeds of Nevada or Oregon are not known in our state.

Chess, cockle, red root and rye are liable to be troublesome in fields of winter wheat, because the seeds are more or less difficult to separate from this grain and for the reason that they require a portion of two years to come to maturity.

Meadows and pastures, especially where the land is not fertile, abound in weeds that require two years or more to produce seeds, such as narrow-leaved dock, bitter dock, bull thistle, carrot, teasel, two kinds of mulleins, night-flowering catchfly, evening primrose, several kinds of fleabane, ox-eye daisy, orange hawkweed, two or three kinds of plantain, Canada thistle, hound's tongue, stick seed, sow thistle, horse nettle, buttercups, toad flax, silvery cinquefoil, and many more, not excluding some annuals, like crab-grass, tickle grass, pigeon grasses. As crops of corn, potatoes, beans, turnips, beets and squashes are ready to harvest at the close of one growing season they are molested more or less by pigeon grasses, several pigweeds, purslane, crab-grass, barnyard grass, tickle grass and a number of others.

In 1897 some seventy-five lots of timothy seeds were examined and the following list of twenty-four species of weeds were found. Doubtless other weeds may still be found in other lots of timothy seed. No sample was entirely free from weeds. Pepper grass was most common, next followed tumble weed and then shepherd's purse:

Amaranthus graecizans, Tumble weed.
Amaranthus retroflexus, Rough pigweed.
Anthemis Cotula, May weed.
Brassica arvensis, Charlock.
Brassica nigra, Black mustard.

Bursa Bursa-pastoris, Shepherd's purse.
Carduus arvensis, Canada thistle.
Carex straminea. A kind of sedge.
Chenopodium album, Pigweed.
Chenopodium filicifolium, Another kind of pigweed.
Lactuca Canadensis, Wild Lettuce.
Lepidium Virginicum, Wild Pepper-grass.
Onagra biennis, Evening primrose.
Panicum capillare, Hair grass, tickle grass.
Plantago lanceolata, Narrow-leaved plantain.
Plantago Rugelii, Rugel's Plantain, one of the broad-leaved plantains.
Poa compressa, Flat-stemmed poa, wire grass.
Potentilla Monspeliensis, Rough cinquefoil.
Prunella vulgaris, Self-heal.
Rumex Acetocella, Field or sheep sorrel.
Sisymbrium officinale, Hedge mustard.
Verbena angustifolia, Narrow-leaved vervain.
Verbena hastata, Blue vervain.
Verbena urticifolia, White vervain.

In examining some 130 lots of clover seeds as found in the market during 1897, thirty-two kinds of weed seeds were found. Sheep sorrel was most common, next to this yellow or bitter dock and green foxtail. Only three samples of clover seed was free from weeds, but possibly some weeds might have been seen if larger quantities had been looked over.

During the year 1908, eleven years later, 47 kinds of weed seeds were found in 122 lots of seed of red clover, a gain of nearly 50 per cent.

During three months from January 1, 1910, in examining 450 lots of seeds of grasses, clovers and alfalfas, besides large numbers of common weeds that we know, were 74 kinds not known to the writer. Of these 74 kinds, probably some will never become weeds of any account. Some of these came with alfalfa from Montana and some were importations from Europe and elsewhere.

Parasitic fungi rank as weeds; such as rusts and smuts of wheat, oats, corn; apple scab, black knot of plum, brown rot of cherry, anthracnose of beans.

SOME MEANS FOR PREVENTING THE INTRODUCTION OF WEEDS AND A FEW RULES FOR THEIR EXTERMINATION.

1. The right kind of a man, who will carefully observe and study the kinds of weeds and their habits, fighting each to the best advantage, i. e. with method.

2. See that all seeds purchased or grown at home for seed are free from seeds of weeds. Although often heard, these words are too little heeded.

3. See that threshing machines, hay racks, grain bags from other farms are well cleaned before used on the farm.

4. Cook or grind screenings and burn chaff when certain weeds are suspected.

5. Send seeds to the Agricultural College, East Lansing, for identification, unless they are known to be harmless.

6. Strive to prevent weeds from ripening seeds. This is especially important late in the season in case of all pigweeds, purslane and others where the flowers are very small and are liable to be overlooked and the seeds ripen before their presence is suspected.

7. For meadow or pasture make the soil very fertile, as most weeds will then be killed or crowded by the better grass and become of little account.

8. Modify the rotation of crops with reference to killing the weeds.

9. Make a specialty of hoed or cultivated crops.

10. Make soiling crops a prominent feature in certain fields.

11. Smother weeds with quick growing and thickly seeded crops, like red clover or rye or buckwheat.

12. Keep some crops growing on the land from early spring till late autumn,—double cropping, i. e., two cultivated crops in one year for barn and cellar instead of one for use and one of weeds.

13. Cultivate thoroughly after a crop is removed.

14. Clean up and avoid leaving any vacant or out of the way places for breeding ground.

15. Where practicable, remove fences and cultivate to the gutters of the highway.

16. Keep some sheep.

17. When once begun, continue the work thoroughly from year to year, giving no quarter to weeds. This is the easiest in the long run and the royal way.

18. Where hand labor is employed, it is far less expensive and much easier to keep weeds down by raking or hoeing once a week than by going over the ground much less frequently.

The habits of a weed determine to a great extent the best mode of fighting it. Certain remedies suggest themselves for creeping perennials, like quack grass and toad flax, while different treatment is best for narrow-leaved dock; and still a different mode of attack may be adopted for crab grass and purslane.

Weeds are annuals, as pigweeds, crab grass, purslane; biennials as bull thistle and mulleins; perennials, like quack grass, Canada thistle, ox-eye Daisy.

Will it pay? The annual cost of successfully fighting a weedy farm of 100 acres in Ontario has been found to be about $75. Good cultivation in the long run pays a greater profit than slipshod culture. It not only kills the weeds, but keeps the soil in condition for securing good crops. It conserves moisture.

Perennial plants cannot gain any if the green leaves are not allowed to appear. The nourishment stored in the root stocks underground will aid the plant to send up slender leaves and if these remain, the plants gain and recruit, but if the leaves start underground and are cut off before coming to the light, these root stocks are drawn on again to furnish food to start more leaves and thus, in time become exhausted.

SEEDS OF MICHIGAN WEEDS.

ASCOMYCETES.

Fig. 1.

Ergot. *Claviceps purpurea.* This is a poisonous fungus, not a seed, mentioned here because it is frequently found as an outgrowth of the grain of many grasses, such as rye, timothy, red top. To mature spores, it must pass to another stage requiring six months or more.

GRASS FAMILY. GRAMINEAE.

Quack-Grass. Couch-Grass. *Agropyron repens* (L.) Beauv. Florets about 1 cm. long, 5-nerved at the short-awned apex: grain seldom produced and still less frequently found apart from the floral glume and palea, linear, about 4 mm. long, base abruptly acute, apex rounded, rounded on the back or outside, inside concave. Our worst weed. Introduced from Europe.

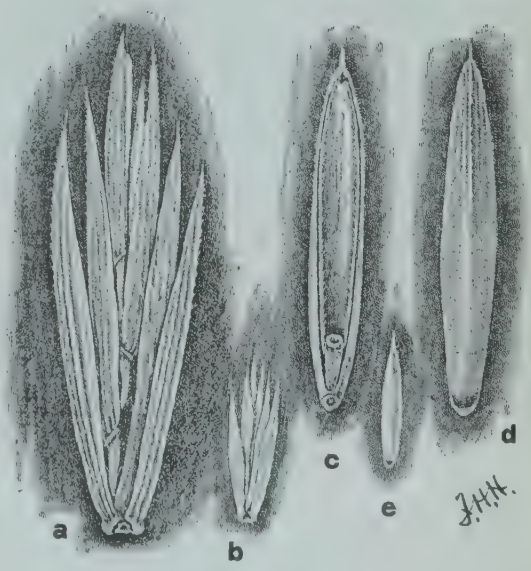


Fig. 2.

Fig. 3.

Wild Oat. *Avena fauta* L. Freed from chaff the floral glume is firm, rough, brown, thinly hairy, about 15 mm. long, awn from near the middle 2-4 cm. long with several firm twists, abruptly bent near the middle, the true grain seldom separated from the firmer floral glume. A bad weed in Oregon and California, seldom seen in Michigan.

Fig. 4.

Field Chess. *Bromus arvensis* (L.) Not often seen in this country; floral glume 6-7 mm. long bearing an awn rather longer; grain much like that of *B. secalinus* which see. Introduced from Europe.

Soft Chess. *Bromus hordeaceus* L. (*Bromus mollis*). Floral glume extending beyond the grain, 5-7 nerved, 6-9 mm. long, grain rounded on the back, shape of a shallow boat, 6.5 mm. long, palea thin with comb-like teeth on the margins Waste places, thin meadows. Introduced from Europe.

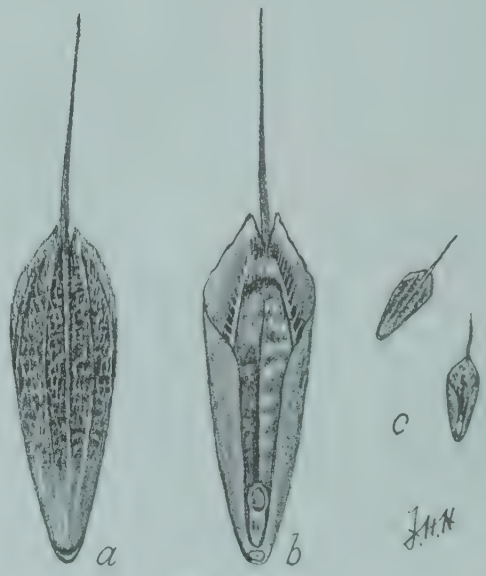


Fig. 5.

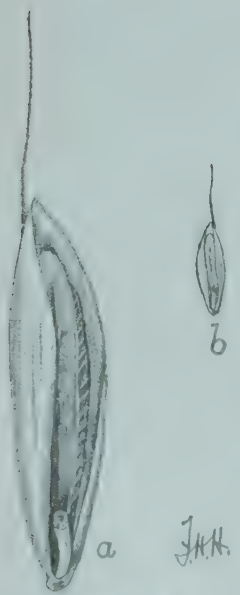
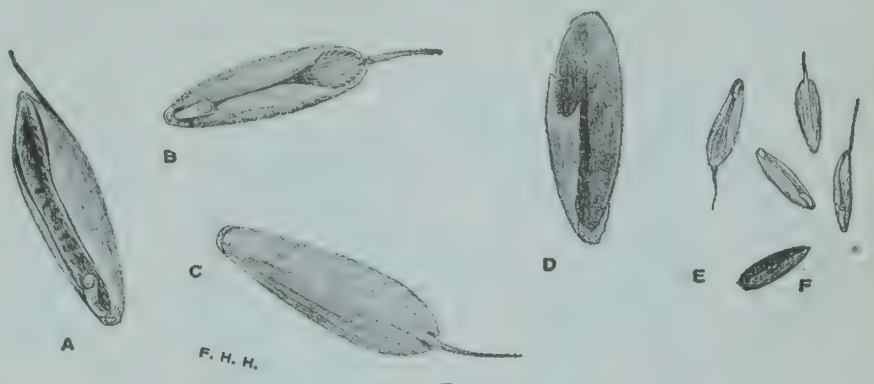


Fig. 6.

Smooth Brome-grass. *Bromus racemosus* L. Florets about 9 mm. long, awn 6-10 mm. long; longer, softer, thinner, with longer awn than found in florets of *B. secalinus* which see. Not often seen in this country. Introduced from Europe.

Chess Cheat. *Bromus secalinus* L. Florets swollen a little above the middle, the floral glume rounded on the back, obscurely 7-nerved, 6-7 mm. long, an awn 3-4 mm. long, more or less; palea covering the concave side, each edge bearing a single row of stiff hairs; glume and palea closely adhering to the grain. Introduced from Europe. A weed in wheat fields.



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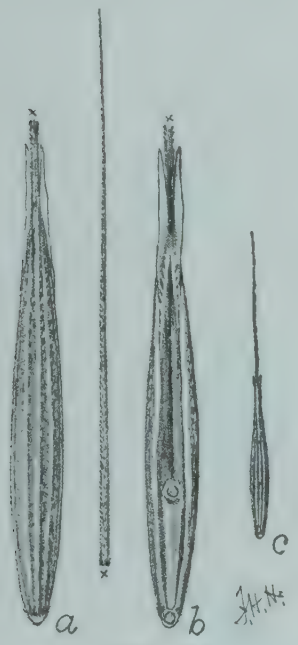


Fig. 8.

Barren Brome Grass. *Bromus sterilis* L. Floral glume minutely roughened, adhering to the grain; 5-7 nerved; 11-15 mm. long; compressed; concave in section. Introduced from Europe, becoming common in the state.

Sand-Bur. Bur-Grass. *Cenchrus tribuloides* L. Spikelets consisting of

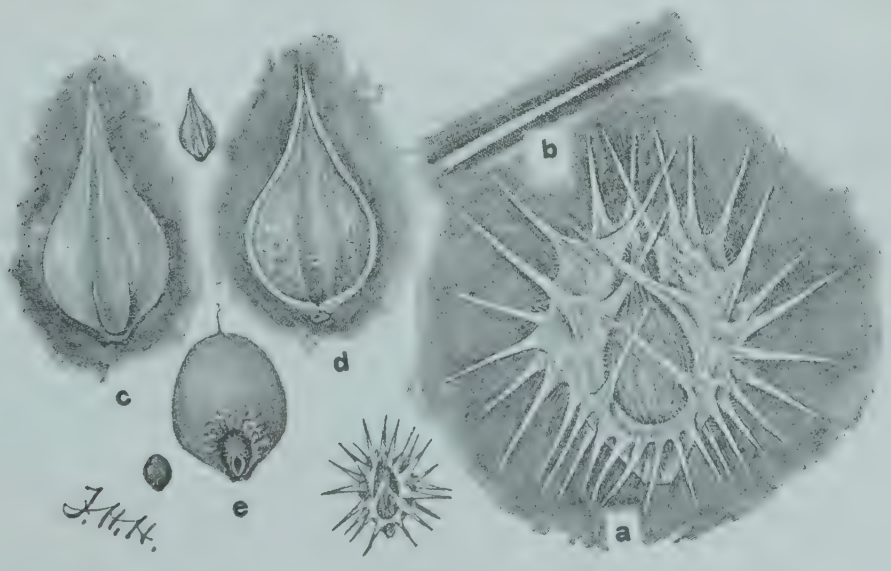


Fig. 9.

the grain and its coverings, broad oval, somewhat flattened, about 7

long, making a disagreeable and formidable bur, often common on sandy land. Native of this country.

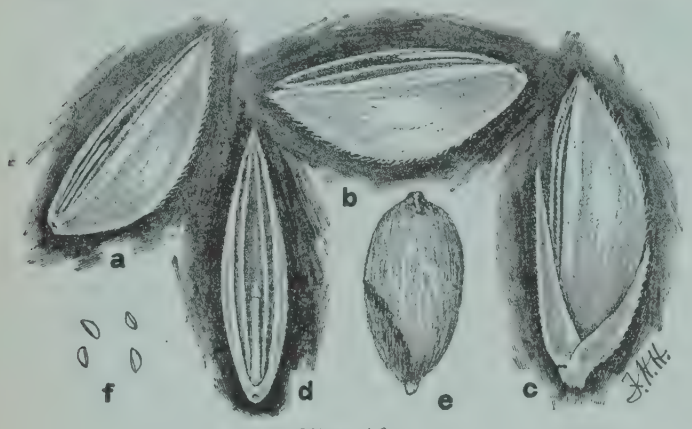


Fig. 10.

Bermuda Grass. *Cynodon Dactylon* L., Pers., (Capriola Dactylon (L.) Kuntze). Floral glume enclosing the grain, smooth, light colored, oval to half-oval, 1.5 to 2 mm. long, in cross section with two long sides and a short side half as long; grain light brown, obovate to oval, a small nipple at the larger end.

The plant seeds in hot countries but not in cool, temperate regions; spreading chiefly by coarse, hard rootstocks. Introduced.

Small Crab-Grass. *Digitaria humifusa* Pers. *Panicum lineare* Kroach. *Syntherisma lincaris* (Kroch.) Nash. Spikelets in the rough, before severe rubbing, ovoid or oblong, flattened, 2 mm. long, first glume minute, second and third as long as the spikelet, soft with very short hairs, one

Fig. 11.

of them 3-nerved, the other 5-nerved; floret after severe rubbing, brown to black, smooth, floral glume of the rounded side curving over the edges below covering with their edges about two-thirds of the palea. Introduced from Europe; becoming troublesome on thin lawns.

Large Crab-Grass. Finger Grass. *Digitaria sanguinalis* (L.) Scop. *Panicum sanguinale L. Syntherisma* (L.) Nash. Spikelets before severe rubbing, oblong, acute, 2.5-3.5 mm. long, first glume on flattened side

Fig. 12.

minute, second on rounded side about half as long as the spikelet, pubescent or nearly smooth, third glume more or less pubescent, 5-7-nerved; floret, after severe rubbing, smooth, edges of floral glume thin. Introduced from Europe. Roots very tough and coming from the lower joints.

Barnyard Grass. *Echinochloa Crus-galli* (L.) Beauv. *Panicum Crus-galli* L. Florets oval, white, yellowish gray or brown, 2.4-3 mm. long, plano-convex, glume on the convex side, highly polished, three obscure longitudinal nerves. Native of this country.

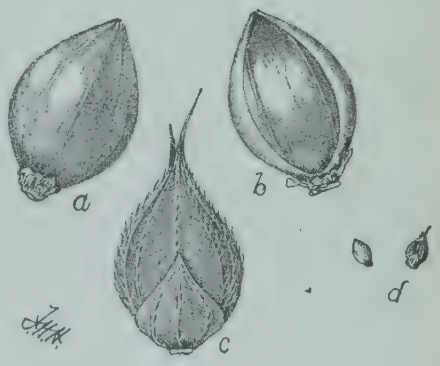


Fig. 13.

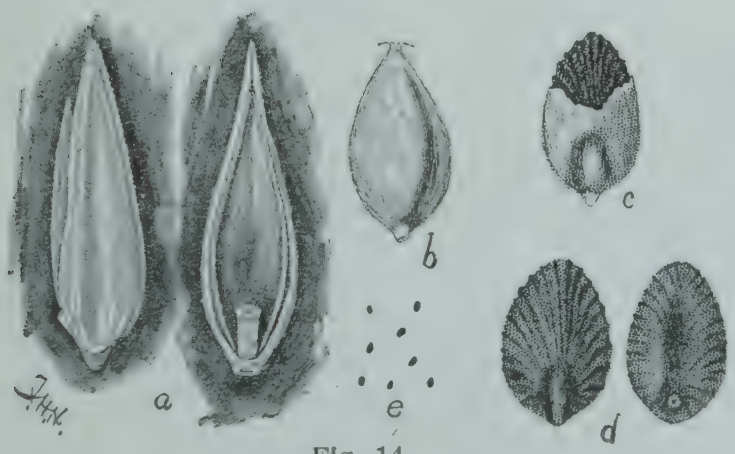
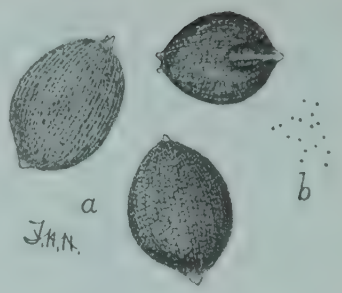


Fig. 14.

Yard-Grass. Wire-Grass. *Eleusine Indica* (L.) Gaertn. Florets light lead color or brown before threshing or much rubbing; grain dark, reddish brown, 1.2-1.4 mm. ovoid with the base abruptly pointed, 3 sided, the corners rounded, a vertical groove along one side; seen from the back with the groove side down and base toward the observer, starting from an oval spot near the base, 10-15 ridges on each side, extend downward and forward. Introduced from some warmer region of the Old World.

Stink-Grass. *Eragrostis megastachya* (Kœler) Link. *Eragrostis major* Host. Grain orange red or wine color .4-.6 mm. long. Broad oval to nearly circular, very slightly flattened, extremities slightly pointed, embryo within one edge near the base, a fine network of dark lines evident under a good lens. Introduced from Europe.



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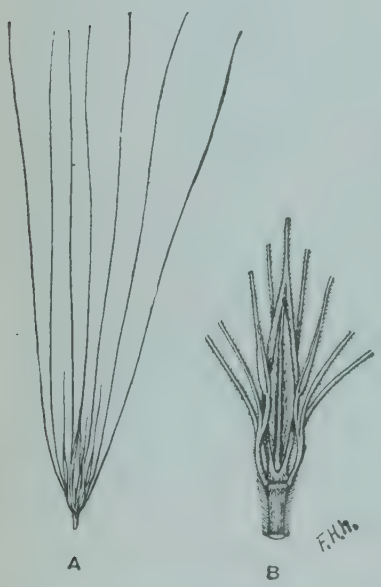


Fig. 16.

Squirrel-tail Grass. *Hordeum jubatum* L. Spikelets in clusters of three, central one only fertile, 5 mm. long, containing a grain adhering to the floral glume and palea, the other two abortive, seven awns in these three spikelets, 4-6 cm. long, four others less than 1 cm. long; awns and fragment of rachis holding the cluster of spikelets together, all barbed upward, making them troublesome for fleeces of sheep and the mouths of animals eating them. Native of this country and widely distributed.

Old Witch Grass. Tickle-Grass. A Tumble-Weed. *Panicum capillare* L. Florets flattened, elliptical, apex abruptly pointed, about 1.5 mm. long, highly polished, leaden gray, lighter at the extremities and along the edges of the glume, five slender light colored nerves join the extremities passing vertically over the glume, two light nerves on the palea. Native to this country.

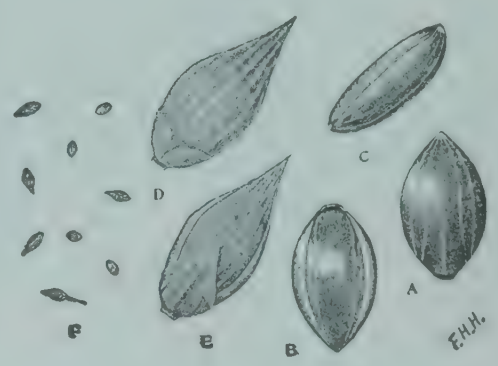


Fig. 17.

Fig. 18.

Tall Smooth Panicum. Switch Grass. *Panicum virgatum* L. Achene surrounded by two persistent shining pieces, the floret; floral glume hard, light brown, oval or ovate-lanceolate 2.5-3.1 mm. long. Apex obtusely pointed. Seldom troublesome, widely distributed.

Fig. 19.

Low Spear-Grass. *Poa annua* L. Florets straw-colored, 2.8-3.1 mm. long, apex smooth, lower half of keel and the base of lateral nerves, having numerous soft hairs. A low annual grass, introduced from Europe.

Flat-stemmed Poa. Wire Grass. Canadian Blue Grass. *Poa compressa* L. Florets lance-obovate, 2-2.5 mm. long, closely resembling those of Poa pratensis, which see. Palea abruptly acute. If well rubbed after threshing, the floret is nearly smooth, otherwise it contains on the lower half numerous webby hairs. Grain reddish brown, both ends pointed, 1-1.4 mm. long. Seldom sown purposely. Sometimes used to adulterate Poa pratensis. In early days this grass was called blue grass by people of New England and New York State. Introduced from Europe.

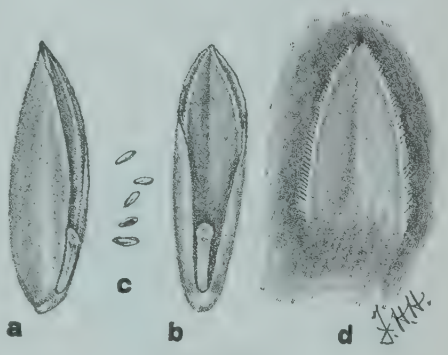


Fig. 20.

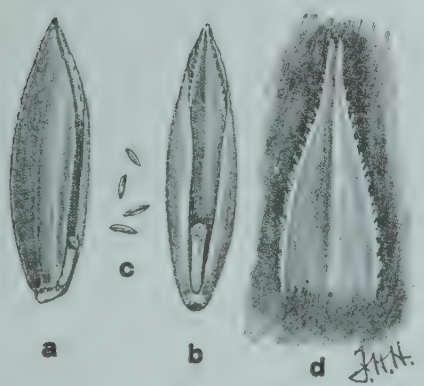


Fig. 21.

June Grass. Kentucky Blue Grass. *Poa pratensis* L. Florets ovate-lanceolate, acute 3-4 mm. long, with three equal sides when seen in transverse section, nearly smooth, if severely rubbed in threshing, otherwise the floral glume is thickly webbed at the base; palea acuminate, grain light brown, elliptical, both ends usually pointed 1.2-1.4 mm. long, in cross sections with three equal sides, one of which has a shallow vertical groove. Compare with Poa compressa. Introduced from Europe.

Rye. *Secale cereale* L. Grain light brown, 6-8 mm. long, elliptical, base acute, apex obtuse and rounded, in cross section the back somewhat acutely rounded, the opposite side with a narrow vertical groove, surface more or less irregularly wrinkled. Introduced from Europe. A bad weed in wheat fields.

Fig. 22.

Pigeon-Grass. Yellow Foxtail. *Setaria glauca* (L.) Beauv. *Chaetochloa glauca* (L.) Scrib. Spikelets light to dark brown, 2.5-3 mm. long; after threshing or much rubbing consisting of each a grain and two firm coverings, known as a floral glume which covers the sides of the somewhat depressed palea, oval, apex slightly 3-toothed, rounded side strongly arched, somewhat V-shaped, roughened crosswise by prominent fine more or less branching ridges; ridges of palea on concave side less prominent. Introduced from Europe. Very common in hoed annual crops.

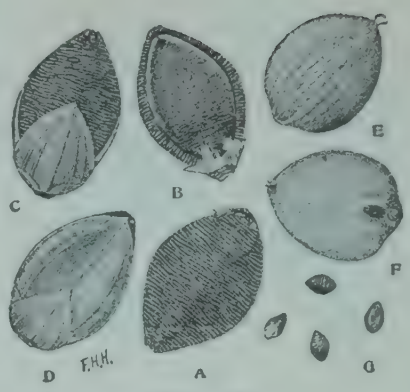


Fig. 23.

Fig. 24.

Green Foxtail. Green Pigeon Grass. *Setaria viridis* (L.)) Beauv. *Chaetochloa viridis* (L.) Nash. Spikelets, light to dark brown mottled, 2-2.3 mm. long, after threshing or much rubbing consisting of the grain and two-firm coverings, the rounded one known as a floral glume which covers the edges of the flattened side, oval, the surface granular and very faintly striate, lengthwise and ridged crosswise. Much resembling Hungarian grass. Introduced from Europe. Found with yellow foxtail.

Porcupine Grass. *Stipa spartea* Trin. Grain inclosed in the floral glume, light brown, 18 mm. long, clothed on the lower half with short brown hairs slanting upward, bearing at the base a sharp, hard, curved beak, when dry the attached awn is twisted for 6 cm. and straight and bent at right angles about 6 cm. When moistened, the awn untwists more or less; twisting and untwisting the beards hold what the beak pierces, thus making it a formidable weapon to enter the skins of sheep, goats and dogs. Fortunately it is seldom abundant. Sandy land Michigan and westward.

Fig. 25.

SEDGE FAMILY. CYPERACEAE.

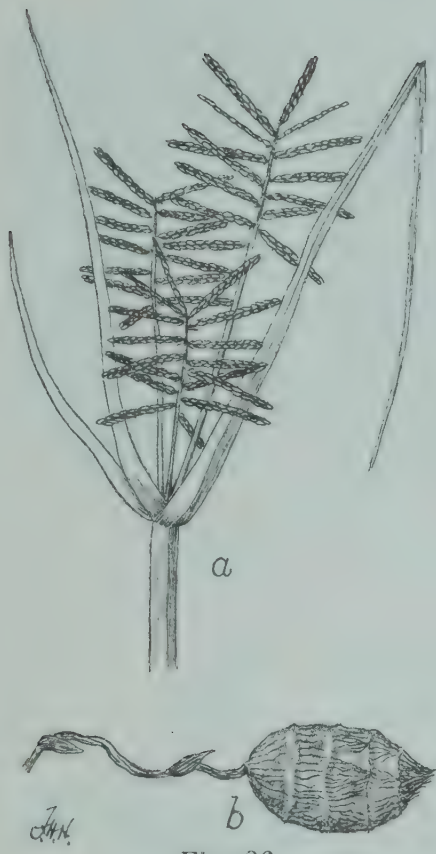


Fig. 26.

Yellow Nut-Grass. *Cyperus esculentus* L. This is a species of sedge, and so far as I have examined, produces no seeds, perhaps having lost that method of reproduction, as it acquired the habit of spreading by tubers here illustrated. In moist soil, sometimes a troublesome weed.

Ovoid Spike-rush. *Eleocharis ovata* (Roth.) R. & S. Spike ovoid, 4-10 mm. long, achene pale to chestnut brown, shining, obovate-oblong, compressed, about 1 mm. long, bearing a triangular tubercle at the apex, and six to eight barbed bristles, 1.3-1.7 mm. long, very variable. Not troublesome except in low land.

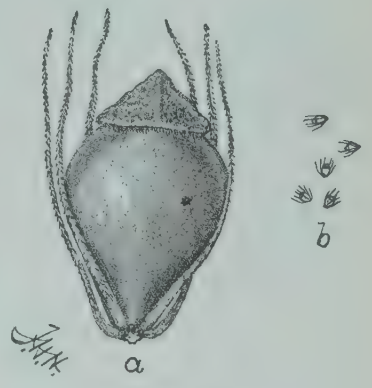


Fig. 27.

RUSH FAMILY. JUNCACEAE.

Fig. 28.

Slender Rush. *Juncus tenuis* Willd. Seeds light brown to amber color, translucent, flattened, oval, half oval, oblong, ovoid, the acute apex curved to one side, about 0.3 mm. long. Dry to moist soil, almost throughout North America, now migrating to all parts of the world. A very common, grass-like rush in this state, seldom recognized by any one under any name, except by a first-rate botanist.

LILY FAMILY. LILACEAE.

Field Garlic. Wild Garlic. *Allium vineale* L. Seeds not seen, apparently seldom produced; bulblets (b) light yellow or almost white, obovoid to elliptical, 7-8 mm. long, when dry. Introduced from Europe. Troublesome in pastures and tainting the flavor of butter; in wheat it taints the flavor of flour. Persistent when introduced. The illustration of grains of wheat (a) are given for comparison.

Fig. 29.

NETTLE FAMILY. URTICACEAE.

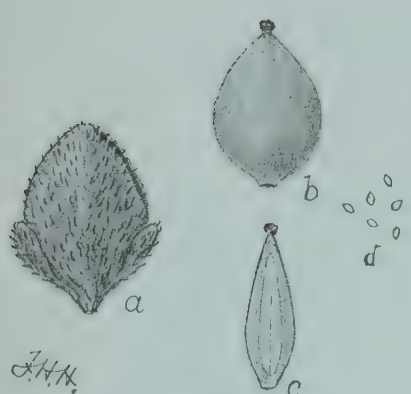


Fig. 30.

Slender Nettle. *Utrica gracilis* Ait. Achenes compressed, lens-shaped, ovate, rarely oval, faces similar, smooth, dull and grayish brown, .9-1.1 mm. long. Native of this country. Compared with U. dioica, this achene is thinner and shorter. Prominent in low pastures.

BUCKWHEAT FAMILY. POLYGONACEAE.

Knot-Grass. *Polygonum aviculare* L. This door-yard weed is in no sense a grass. Achenes unequally 3-sided, ovoid, acute, angles obtuse, surface, dull, light to dark reddish brown, finely granular and striate lengthwise. 1.8-2.2 mm. long, usually with the remains of calyx attached. Native of this country. Common about door-yards.

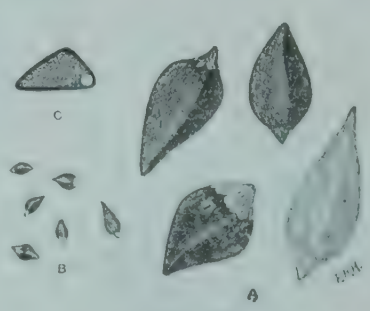


Fig. 31.

Fig. 32.

Wild Buckwheat. *Polygonum Concolvulus* L. Achenes dull, jet-black, equally 3-sided, ellipical to obovoid, minutely granular often with faint longitudinal striation, the faces often more or less concave, the angles rounded, 2.5-3.5 mm. long, sometimes with the remains of calyx attached. Introduced from Europe. Often climbing up corn stalks.

Erect Knotweed. *Polygonum erectum* L. Achenes dull, light to dark brown, unequally 3-sided, ovoid or rhombic, finely granular and striate lengthwise, the faces sometimes concave, the angles rounded, 2.5-3 mm. long, sometimes with the remains of calyx attached. Native to this country. Of little account.

Fig. 33.

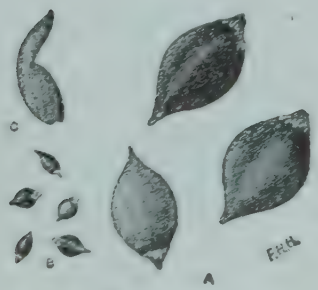


Fig. 34.

Smart-weed. *Polygonum Hydropiper* L. Achene dull, granular, light to dark reddish brown, lenticular, acutely and narrowly or broadly elliptical, or 3-sided, apex acute, concave on the sides, angles obtuse, 2-3 mm. long, sometimes with the remains of the dotted calyx attached. Introduced from Europe. Wet land.

Dock-leaved or Pale Persicaria. *Polygonum lapathifolium* L. Achene shining, dark to chestnut brown, 2-2.2 mm. long, flattened, circular to broadly ovate with abruptly pointed apex, the base obtuse or bearing the remains of the thin calyx. Introduced from Europe. Low wet places.

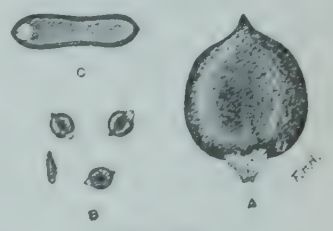


Fig. 35.

Shore Knotweed. *Polygonum littorale* Link. So far as the achenes are concerned, they are identical with those of P. aviculare above described. Native of this country. On hard or thin places, especially when newly graded.

Pennsylvania Persicaria. *Polygonum Pennsylvanicum* L. Achene shining, jet-black, flattened, surface very slightly uneven and granular

Fig. 36.

nearly circular with a short abrupt apex, edge rounded, 2.5-3 mm. long, often bearing the remains of the calyx. Native to this country. Occasional in annual crops.

Lady's Thumb. *Polygonum Persicaria* L. Achene shining, jet-black, surface finely uneven, much flattened with rounded edges or with 3 nearly equal concave faces, the edges faintly angled along the center, broadly ovate, base abtuse or bearing a portion of the calyx, apex abruptly pointed, 2-2.3 long. Introduced from Europe. Waste places and stubble ground.

Fig. 37.

Fig. 38.

Climbing False Buckwheat. *Polygonum scandens* L. Achene black, shining, in cross-section sides flat or concave, corners rounded, obovate, in vertical outline sides rounded to an obtuse apex, from rounded sides to base slightly concave, base acute, 3.5-4 mm. long when freed from the persistent base of the calyx. Woods and shady places. Not prominent as a weed.

Sorrel. Sour Dock. *Rumex Acetosa* L. Calyx-wings broadly ovate or orbicular, heart-shaped 3.5-4.5 mm. long, achene shining, with 3 equal

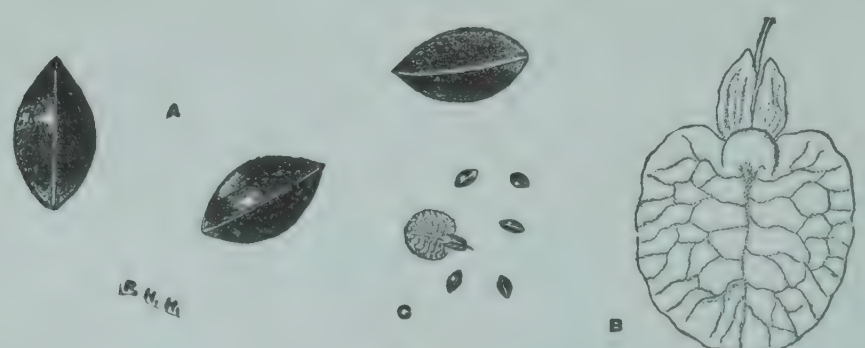


Fig. 39.

sides, broadly oval, both ends abruptly pointed, the thin edges usually lighter colored than the dark brown or black convex faces, 1.5-2 mm. long. Introduced from Europe. Not common.

Sheep Sorrel. *Rumux Actosclla* L. Achenes usually closely covered by dull reddish brown, finally roughened calyx, which is removed with difficulty; achenes shining with 3 equal sides, broadly oval, the base

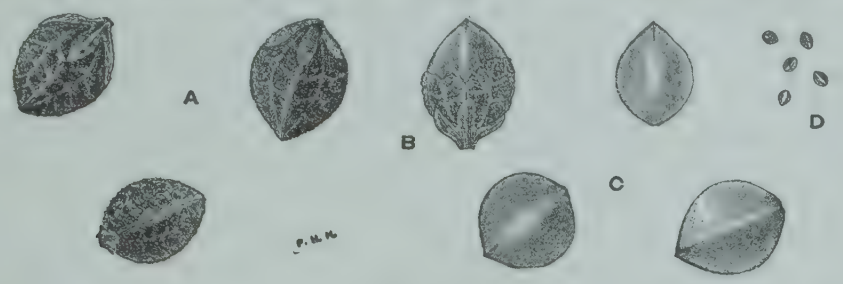


Fig. 40.

rounded, the apex abruptly pointed, sides convex, reddish brown or amber color, corners obtuse, darker colored. Native of this country, though in large part introduced from Europe. Very common in thin sandy meadows.

Narrow-leaved or Curled Dock. *Rumex crispus* L. Achene covered by 3 brown heart-shaped calyx-wings, which are 2.5-3.5 mm. long, each bearing an ovoid, acute tubercle; one of them is 1.5 mm. long, the other two smaller. Achene ovoid, 3-angled, shining, rich reddish-brown, 1.3-1.8 mm. long, .7-1.4 mm. wide, in transverse section the angles promi-

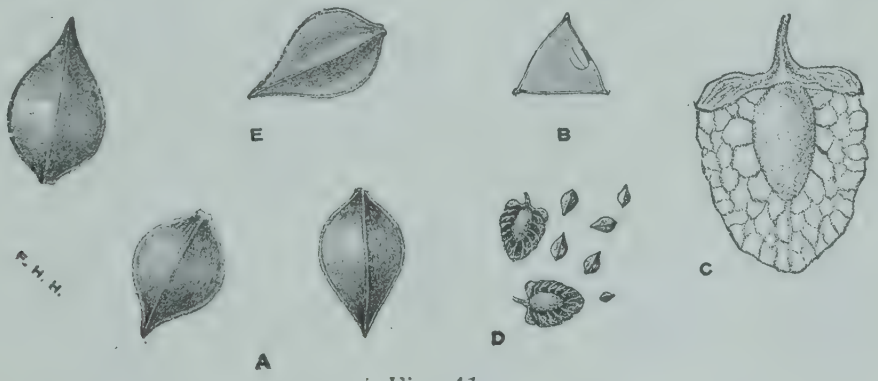


Fig. 41.

nent, convex sides and angles concave near the base; base abruptly acute; when viewed vertically sides and angles concave near the apex; apex abruptly acute, compare these notes with those concerning R. obtusifolius. Introduced from Europe. Very common on low land and in meadows.

Broad-leaved or Bitter Dock. *Rumex obtusifolius* L. Achene covered by three brown, hastate-deltoid calyx-wings, which are about 4 mm.

Fig. 42.

long, each bearing an ovoid-elliptical tubercle, one of them 1.5 mm.

long, the other two very narrow, rudimentary. Achenes ovoid, 3-angled, less polished than those of R. crispus, light brown, 2-2.4 mm. long, 1-1.4 mm. wide, angles in transverse section slight, sides convex, usually in a greater degree than in the specie just named, vertically sides and angles very slightly concave or straight near the base which is abruptly acute; sides and angles near the apex scarcely concave or straight; apex acute. Introduced from Europe. Not very common.

Patience Dock. *Rumex Patientia* L. Calyx-wings circular-heart shaped, 4-6 mm. long, one of them bearing a prominent ovoid tubercle; achene ovoid-elliptical, 3-angled, somewhat polished, shining, light-brown, 2.5-3.5 mm. long, 1.7-2 mm. wide, angles prominent, sides straight, in transverse section, not counting the angles, base rounded, not counting the abrupt point, when seen vertically, the sides near the apex are straight or slightly concave. Introduced from Europe. Not common.

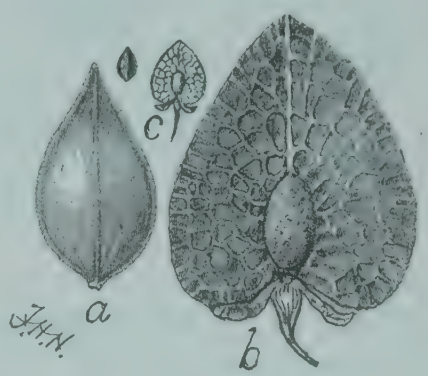


Fig. 43.

Willow-leaved Dock. *Rumex Mexicanus* Meisn. *Rumex salicifolius* Weinm. Calyx-wings triangular-ovate, about 3 mm. long, each bearing a large tubercle; achene dark reddish brown, smooth, shining,

Fig. 44.

1.8-2.2 mm. long, ovoid, angles prominent, the sides viewed transversely rounded, the sides of the base as viewed vertically, rounded, straight or slightly concave, near the apex straight or concave. A native of Northeastern North America. Not common.

GOOSEFOOT OR PIGWEED FAMILY. CHENOPODIACEAE.

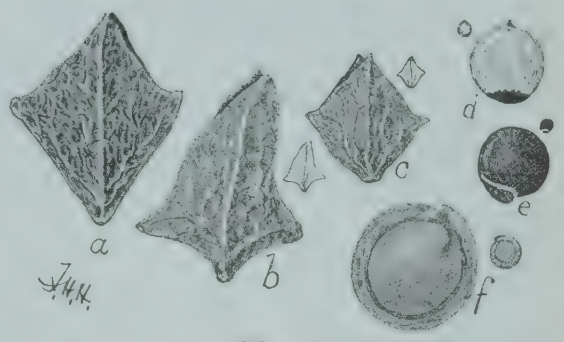


Fig. 45.

Spreading Orache. *Atriplex patula* L. Seeds are likely to occur in either of three different guises, depending upon the degree of their ripeness or the amount of threshing to which they have been subjected.

Achenes thin, dull, granular, gray, closely fitting the seed; seed jet-black, shining, flattened, nearly circular, edge bluntly rounded, and notched in one place, a groove leading from one side of a margined protuberance part way to the center of the face, 1.5-1.8 mm. in diameter. Introduced from Europe. Seldom troublesome.

Pigweed. Lamb's Quarters. *Chenopodium album* L. Seeds are likely to occur in either of three different guises dependent upon the degree of their ripeness or the amount of threshing to which they have been subjected. The figure shows these conditions admirably.

Fig. 46.

Seeds black, dull or somewhat glistening, gray if not pretty clean; nearly circular; somewhat lens-shaped, one side usually more nearly flattened than the other 1-1.4 mm. in diameter, the edge bluntly rounded, the more convex side bearing a curved groove leading from one side of the marginal protuberance to near the center of the face, surface finely uneven, often with a faintly evident radiating striatian. Introduced from Europe. Very common in annual crops.

Mexican Tea. *Chenopodium ambrosioides* L. Note remarks under last preceding description concerning different stages of cleaning. Seeds smooth, shining, reddish brown, to black, thickly double convex with scarcely a trace of a hem-like margin, circular, short kidney-shaped or ovate with a notch on the edge, .6-.8 mm. long. Introduced from tropical America. Not prominent.

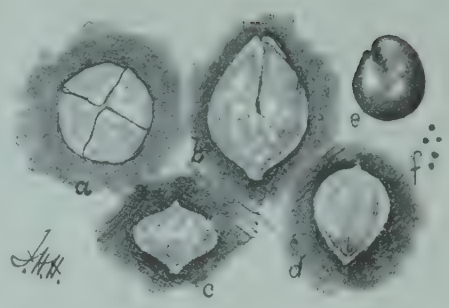


Fig. 47.

Fig. 48.

Jerusalem Oak. *Chenopodium Botrys* L. Concerning different states of cleaning, note remarks above under C. album.

Seeds perfectly cleaned with great difficulty, brown to black or gray, when imperfectly cleaned, slightly flatted on two sides, circular or round, kidney-shaped, sometimes with a hem-like margin, on one side a faint groove from the margin to near the center of the face, .6-.8 mm. in diameter. Introduced from Europe. Not prominent.

Oak-leaved Goosefoot. *Chenopodium glaucum* L. Concerning the different stages of cleaning note remarks above under C. album.

Seeds brown to black, more or less slightly granular, shining, flattened on two sides, circular edge bluntly rounded, with a single notch from which on one side extends a slight depression toward the center of the face. .5-.8 mm. in diameter. Introduced from Europe. Occasional on moist soil.

Fig. 49.

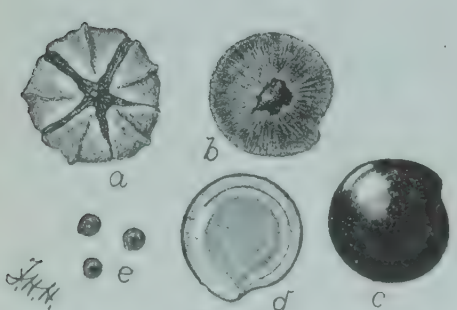


Fig. 50.

Maple-leaved Goosefoot. *Chenopodium hybrium* L. Concerning the different stages of cleaning, note remarks above under C. album.

Seeds black, shining, greenish gray if not fully cleaned, nearly circular, lens-shaped, equally convex, 1.2-1.8 mm. in diameter, with a notch on the edge, from which on one side a grove leads to near the center of the face, surface finely uneven, often with a faintly evident radiating striation. Native of this country. Of little importance.

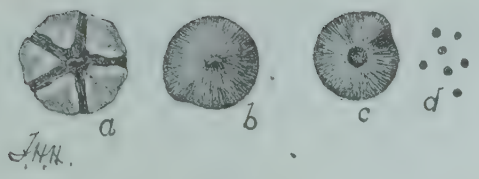


Fig. 51.

Many-seeded Goosefoot. *Chenopodium polyspermum* L. Concerning different stages of cleaning, note remarks above under C. album.

Seeds finely glandular, shining, jet-black, greenish gray, when not fully cleaned, nearly circular or broadly kidney-shaped, sides equally convex, .6-1.1 mm. in diameter, with a notch on the edge from which on one side, a groove leads to near the center of the face. Introduced from Europe.

Winged Pigweed. *Cycloloma atriplicifolium* (Spreng.) Coulter. Seeds are likely to occur in either of three different guises depending upon the degree their ripeness or the amount of threshing to which they have been subjected. See the figure of this species. Seeds granular, circular, dull, jet-black, or gray in case the thin ovary remains, 1.3-1.7 mm. in diameter, lower face convex, the upper slightly convex if mature, with a slight notch on the rounded edge, the lower face bearing a slight curved groove, leading from the notch to near the center, the upper face with a light spot at the center. Introduced from western United States. A tumble weed, not common.

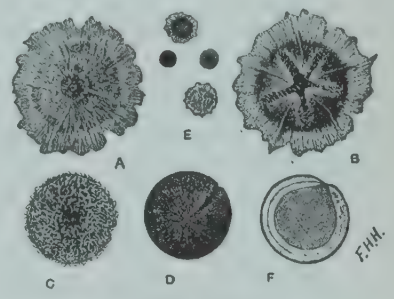


Fig. 52.

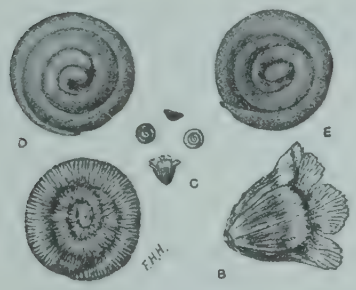


Fig. 53.

Russian Thistle. *Salsola Kali tenuifolia* G. F. W. Mey. This is not a thistle nor a cactus, but a pigweed. Concerning different stages of cleaning, note remarks above under Chenopodium album (see the figures). Seeds conical, the apex flattened or concave, both sides showing the long coiled embryo, light gray in color, about 2 mm. in diameter. Introduced from northern Europe into the north west and from there into Michigan. Well advertised, though not of high rank as a weed in this state. A tumble weed.

AMARANTH FAMILY. AMARANTHACEAE.

Western Water Hemp. *Acnida tuberculata Moq.* Seeds smooth, highly polished, brown to jet-black, double convex, nearly circular, with a slight notch at one edge, .6-.8 mm. in diameter, smaller, lighter colored, and thin margins less conspicuous than those found on the seeds of *Amaranthus circaezans.* There are three varieties with seeds much the same as these. Native of low ground in central and southern Michigan.

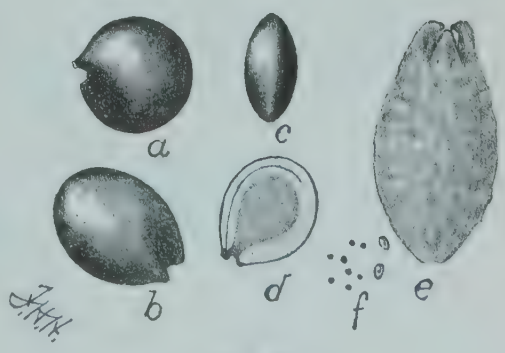


Fig. 54.

Prostrate Amaranth. *Amaranthus blitoides* S. Wats. Seeds smooth, highly polished, jet-black, double convex, nearly circular, with a slight notch at one edge, 1.4-1.5 mm. in diameter. Introduced from west of

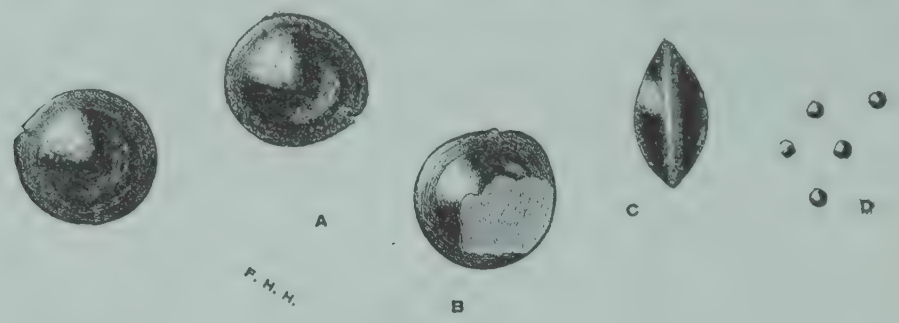


Fig. 55.

the Rocky Mountains. It thrives on sandy and gravelly banks. Margin of this seed is less pronounced than in either of the other three noticed above. Found almost everywhere in fields of Michigan. Introduced from tropical America. Very common in annual hoed crops.

Tumble weed. *Amaranthus graecizans* L. Seeds smooth, highly polished, jet-black, double convex, nearly circular with a slight notch

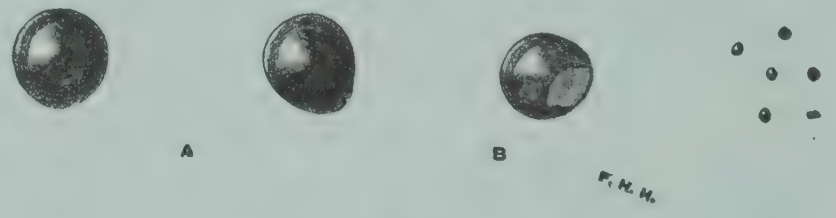


Fig. 56.

at one edge, .7-1 mm. in diameter. Compare with *Acnida*. Introduced from tropical America. It needs sand or gravel.

Fig. 57.

Slender Pigweed. *Amaranthus hybridus* L. (*A. chlorostachys*) Seeds smooth, highly polished, jet-black, double convex, broadly ovate, with a slight notch at the narrow extremity, 1.1-1.4 mm. long. Distinguished from the preceding species by having a seed ovate instead of circular. Introduced from tropical America. Not abundant.

Rough Pigweeds. *Amaranthus retroflexus* L. Sometimes incorrectly called red-root. Seeds smooth, highly polished, jet-black, double convex,

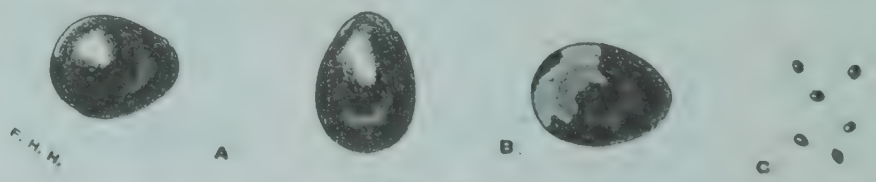


Fig. 58.

broadly ovate, with a slight notch at the narrow end, .9-1.2 mm. long. The seeds of this and the next preceding are ovate, while those of the

first two are very nearly circular. When seen edgewise, the hem-like margin of this seed is less prominent then in either of the preceding three noticed above. Found almost everywhere in annual crops. Introduced from tropical America.

KNOTWEED FAMILY. ILLECEBRACEAE.

Fig. 59.

Knawel. *Sclernathus annuus* L. As the seed is single for each flower, it is unnecessary for the ovary to open; the small, hardened, ten-angled calyx with its five thick lobes aid in protecting and distributing the seed within. The seed is seldom seen. Calyx straw-colored, obovoid, 2 mm. long besides the five spreading, membranaceous lobes, which are nearly as long. A low spreading plant, resembling some kinds of chickweed.

AIZOACEAE.

Carpet-Weed. *Mollugo verticillata* L. Seeds orange-red, shining, flattened, kidney-shaped or ovoid, .4-.6 mm. long, concave on the thinner edge from which protrudes a nipple-like point, a low central ridge passing over the rounded edge. Native of warmer America. Needing sand.

Fig. 60.

PINK FAMILY. CARYOPHYLLACEAE.

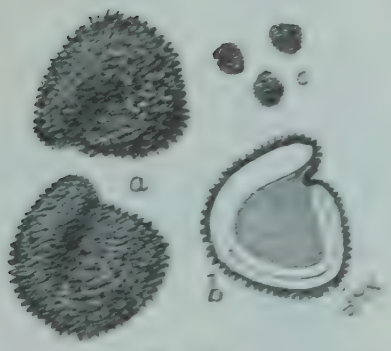


Fig. 61.

Cockle. *Agrostemma Githago* L. Flowers rose-colored; pod erect, ovoid, about 16 mm. long; seeds dark brown to black, wedge-shaped-triangular, appearing as though the two extremities were bent together; surface covered with curved rows of conspicuous teeth, one side 3-3.5 mm. long. Introduced from Europe. In no sense a weed except in wheat fields.

Thyme-leaved Sandwort. *Arenaria serpyllifolia* L. Flowers white; seeds reddish brown to lead color, slightly flattened, circular to short-kidney-shaped. Each side covered with 4-5 curved rows of smooth, oval tubercles, giving the appearance of having two extremities bent together, about 5 mm. in diameter. Naturalized from Europe, delighting in light, poor soil. When well grown it becomes a tumbleweed.

Fig. 62.

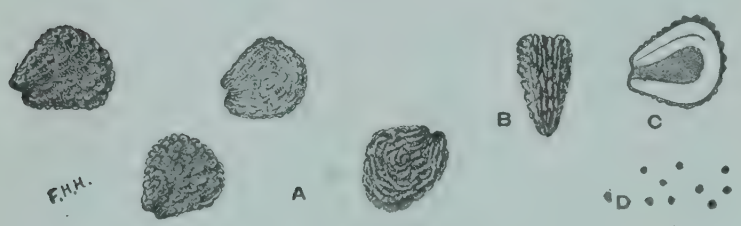


Fig. 63.

Larger Mouse-ear Chickweed. *Cerastium vulgatum* L. Flowers white; pods cylindrical; seeds light-reddish yellow to dark reddish brown; slightly flattened, 4-sided, 2 of them straight, converging, one rounded, the other narrow and notched. Some of them ovoid, others nearly circular, covered with a few irregularly curved rows of tubercles, .4-.8 mm. in diameter. In large part introduced from Europe, though a native of this continent.

Bouncing Bet. Soapwort. *Saponaria officinalis* L. Flowers white; seeds dark lead-color, flattened, short-kidney-shaped to circular with notch on one side, 2 mm. across, more or less, with 6-7 curved rows of short, shiny tubercles. Naturalized from Europe, delighting in sandy soil.

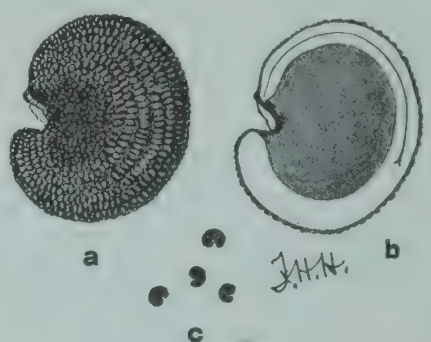


Fig. 64.

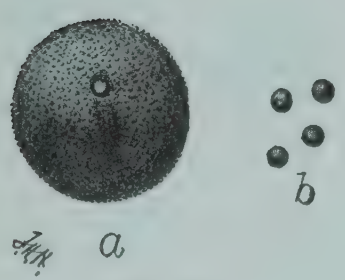


Fig. 65.

Cow-herb. *Saponaria Vaccaria* L. Seed dull, jet-black, slightly roughened by great numbers of minute points, nearly spherical, 2.3 mm. in diameter. An annual very troublesome in spring wheat. Introduced from Europe.

Sleepy Catch-Fly. *Silene antirrhina* L. Flowers pink; seeds lead-color, slightly flattened, circular to short-kidney-shaped, each side covered with 5-6 curved rows of pointed tubercles giving the appearance of having two blunt extremities bent together. .5-.7 mm. across. Compare seeds with those of *Arenaria* above described. When in flower, two of the upper internodes are glutinous. Only found on thin soil.

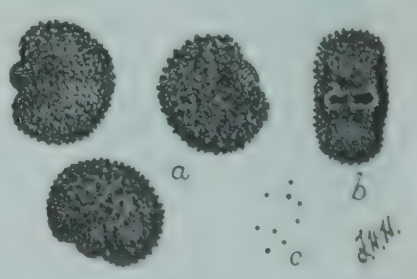


Fig. 66.

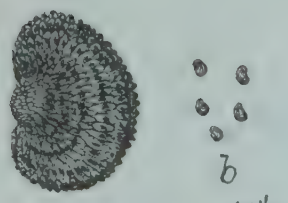


Fig. 67.

Forked Catch-fly. *Silene dichotoma* Ehrh. Seeds reddish-brown, flattened, the three sides and the corners rounded, thickest at one corner narrowing to the side opposite; seed scar in the middle of the narrow side, four curved rows of tubercles on either side of the seed extending to the scar, diameter 1.3 mm., the thick edge concave, containing 6-7 rows of tubercles.

Bladder Campion. *Silene latifolia* (Mill.) Britton & Randle. *Silene* (Moench) Garcke. Flowers white; pod covered by an inflated calyx, seeds dull grayish brown, flattened, wedge-shaped, oval or 3-sided, 1-1.7 mm. across, 5-7 curved rows or tubercles on each side. Naturalized from Europe.

Fig. 68.

Night-flowering Catch-Fly. *Silene noctiflora* L. Flowers white; seeds dull grayish brown, very slightly flattened, oval or short kidney-shaped,

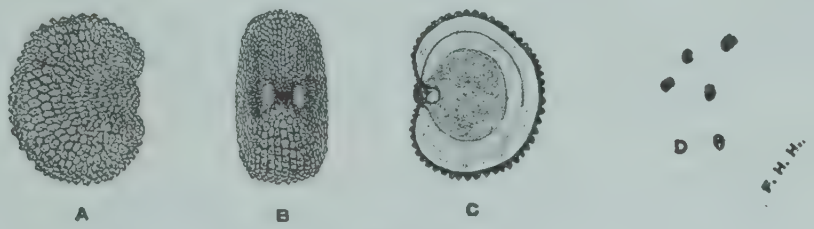


Fig. 69.

nearly 1.5 mm. across, with 8-10 curved rows of tubercles on each side. Naturalized from Europe.

Fig. 70.

Spurry. *Spergula arvensis* L. Flowers white; seeds jet-black, except a narrowly winged, light-colored margin, slightly flattended, circular in outline 1-1.5 mm. across, with a slight notch on one side, surface often sprinkled with delicate, fragile, light-colored prickles. Introduced from Europe. Thriving on poor, sandy land.

Common Chickweed. *Stellaria media* (L.) Cyrill. *Alsine media* L. Flowers white; seeds reddish yellow to dark brown, somewhat flat-

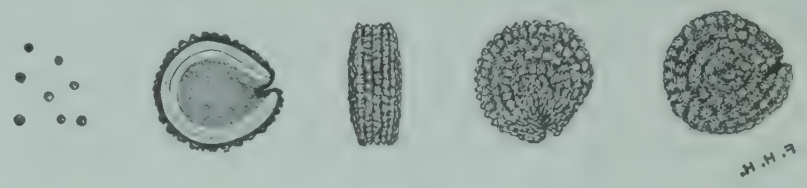


Fig. 71.

cles, giving the appearance of having the two extremities bent together, tened, nearly circular, each side covered with 5-6 curved rows of tuber- about 1 mm. in diameter. Introduced from Europe, thriving in cool weather in shade.

PURSLANE FAMILY. PORTULACACEAE.

Purselane. Pussley. *Portulaca oleracea* L. Flowers yellow, seeds jet-black, shining, flattened, wedge-shaped, having three rounded nearly equal sides, broadly oval or almost circular, often having a curved tooth or point on one side, with 3-4 curved rows of minute tubercles. Seed .5-.8 mm. in diameter. Naturalized from the southwest. Every gardener knows how difficult it is to exterminate this weed.

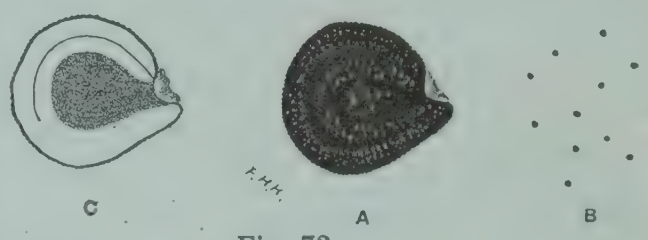


Fig. 72.

CROWFOOT FAMILY. RANUNCULACEAE.

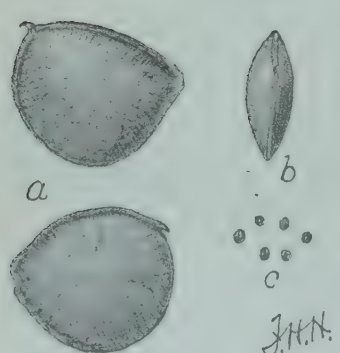


Fig. 73.

Small-flowered Crowfoot. *Ranunculus abortivus* L. Achene light brown to straw colored, 0.8-1.2 mm. in diameter, oblong, 0.3 mm. thick, when seen in cross sections, surface uneven with minute wrinkles, pits and dots flattened, broad oval to circular, three-sided, bearing the remains of a short curved style. Rich, low woods, not a common weed.

Bitter or Tall Buttercup. *Ranunculus acris* L. Achenes dull, dark brown, two-beaked, somewhat lens-shaped, 3-4 mm. long, one edge very slightly convex, the other prominently so, or somewhat semicircular in outline, hemlike-like margin, obscure. Introduced from Europe. Low land.

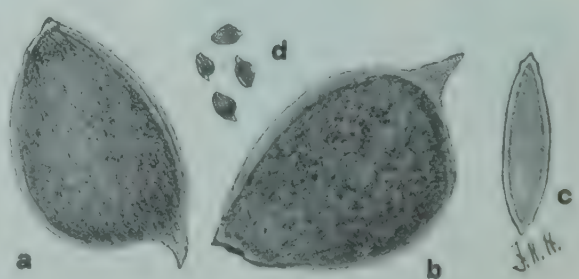


Fig. 74.

Fig. 75.

Bulbous Buttercup. *Ranunculus bulbosus* L. Achenes dull brown, nearly circular, diameter 3-4 mm.; beak short, turned to one side, surrounded by a narrow, hem-like margin. In June, many meadows of New England and New York are yellow with great numbers of flowers. Introduced from Europe. Upland; fortunately not yet common in this state.

Creeping Buttercup. *Ranunculus repens* L. Achenes plump, dull, light-brown, nearly circular, diameter 3-4 or more mm.; beak more or less hooked, hem-like margin conspicuous. This species usually seeds very sparingly, but when once introduced, it looses no time in spreading by creeping stems. Introduced from Europe. Moist land; a rapid spreader by runners.

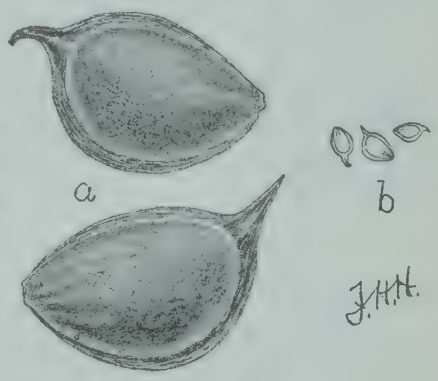


Fig. 76.

POPPY FAMILY. PAPAVERACEAE.

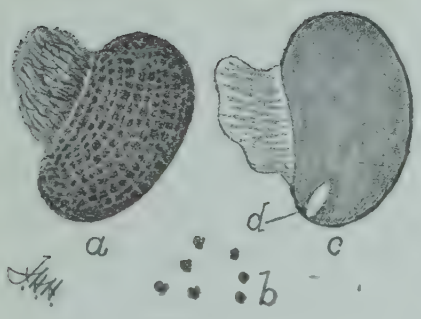


Fig. 77.

Celandine. *Chelidonium majus* L. Yellow sap, yellow flowers; seeds dark brown to almost black, ovoid, 1.2-1.5 mm. long, with 10-12 curved vertical rows of small square depressions on each side; projecting from one side a prominent white or cream-colored ridge, irregularly wrinkled when dry. Introduced from Europe. Persistent.

MUSTARD FAMILY. CRUCIFERAE.

Yellow or Small Alyssum. *Alyssum alyssoides* L. Flowers yellow; fruit nearly circular; seeds rich yellowish brown, about 1.5 mm. long, nearly straight on one edge, flattened slightly, convex on each side or one side flat, surrounded by a thin wing. Cotyledons accumbent. Introduced from Europe.

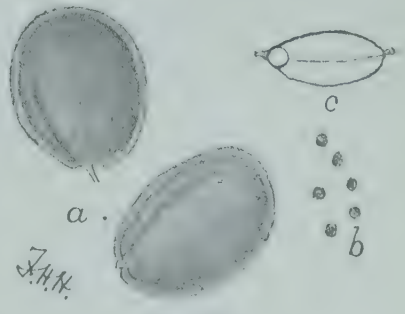


Fig. 78.

Yellow Rocket. Winter Cress. *Barbarea vulgaris* R. Br. (*Barbarea Barbarea* L. Mac. M.) Seeds roughened, dull, light brown, irregularly flattened, broad oval, circular-oval, circular-oblong, cotyledons accumbent. Introduced from Europe.

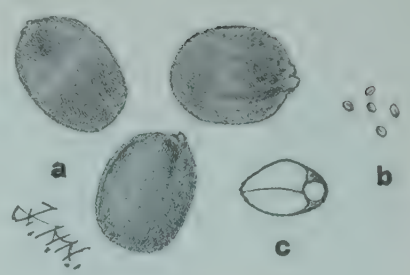


Fig. 79.

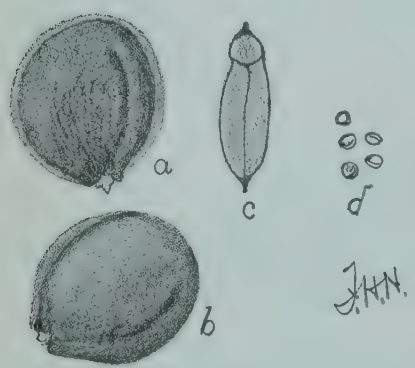


Fig. 80.

Hoary Alyssum. *Berteroa incana* (L.) D. C. Flowers white; pods oval, flattened; seeds reddish brown, circular, broad oval, or rhombic in outline, about 1.5 mm. in diameter, flat on one side showing a slight groove, the other side convex, irregular owing to pressure in the pod. Cotyledons accumbent. Introduced from Europe. A thrifty weed of the mustard family.

Charlock. *Brassica arvensis* (L.) B. S. P. Pods tipped with a flattened elongated-conic, often 1-seeded beak. See also cuts of rutabaga and black mustard. Introduced from Europe. See statements last above.

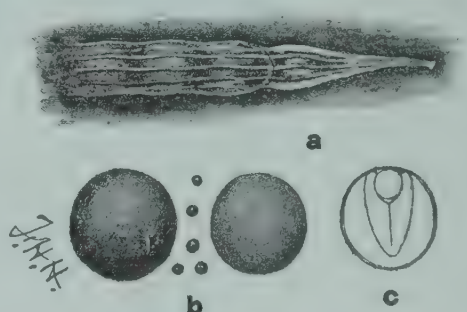


Fig. 81.

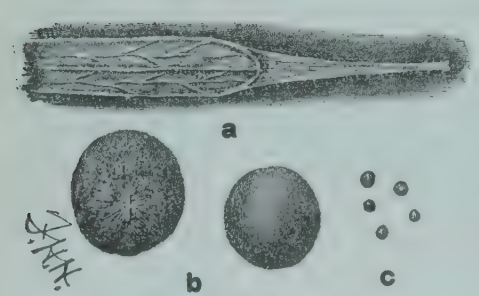


Fig. 82.

Rutabaga. *Brassica campestris* L. Seed dull, light or dark reddish brown, roughened by an indistinct net work of ridges, very nearly spherical, 1.4-1.8 mm. in diameter. Much cultivated, inclined to escape. Included here for comparison with other species. Introduced from Europe.

Indian Mustard. *Brassica juncea* (L.) Cossos. See also cuts of turnip and black mustard. Introduced from Europe.

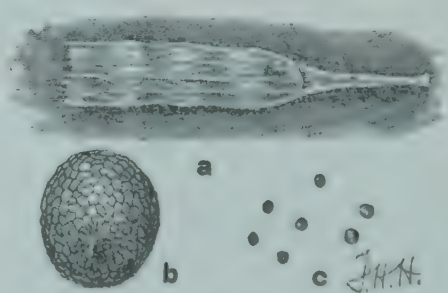


Fig. 83.

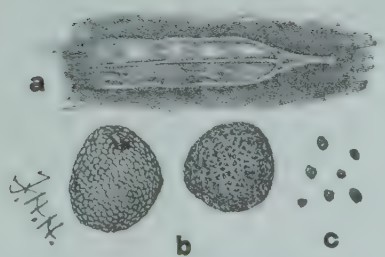


Fig. 84.

Black Mustard. *Brassica nigra* (L.) Koch. Seeds dark brown to reddish brown, 1-1.7 mm., spherical, or broadly oblong, not flattened. The surface of well developed specimens presents a delicate but evident net work of fine ridges which appear under the lens as dark lines. The scar (hilum) is a whitish, elevated spot, at one extremity of the oblong seeds. See cuts of seeds of turnip. Introduced from Europe. A vigorous persistent weed.

Small-Fruited False-Flax. *Camelina microcarpa* Andrz. Flowers small, yellow; pods pear-shaped, flattened, about 6 mm. long, surrounded by a vertical ridge; seeds reddish brown, granular, usually broad-oval, about 1 mm. long, slightly flattened, the vertical ridge much less prominent than in C. sativa. When wet the seed is soon covered with mucilage. Not yet very common. Naturalized from Europe.

Fig. 85.

False Flax. *Camelina sativa* (L.) Crantz. The common name is derived from the fact that it is a weed of flax fields in Europe. Flowers small, yellowish; pods pear-shaped, slightly flattened, 8-10 mm. long,

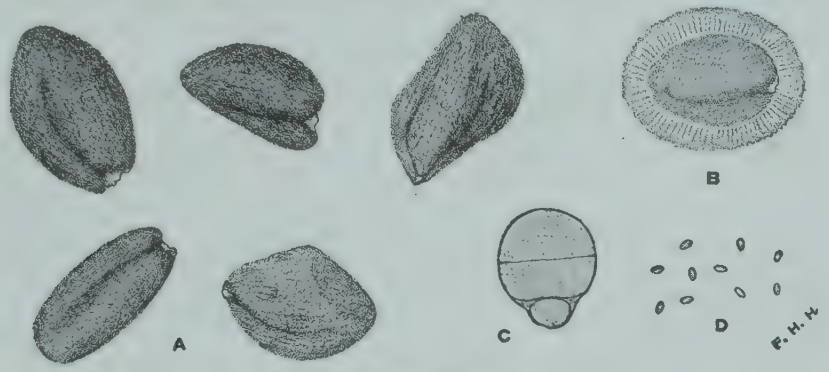


Fig. 86.

surrounded by a vertical ridge. Seeds reddish yellow, granular, usually oval. 2-3 mm. long, one side flat or roundish, the other furnished with a prominent vertical or oblique ridge. Seed incumbent. When wet the seed is soon covered with mucilage. Naturalized from Europe.

Shepherd's Purse. *Capsella Bursa-pastoris* (L.) Medic. *Bursa Bursa-*

Fig. 87.

pastoris (L.) Britton. Flowers small, white; pods flat, nearly triangular, about 4 mm. long. Seeds reddish yellow, granular, oblong, slightly

flattened, 1 mm. or less long. Each side usually bearing two longitudinal grooves, separating the surface into three nearly equal parts, these grooves indicating the position of the parts of the embryo. When placed in water, a copious coat of transparent mucilage appears on the surface. In Nevada and Colorado a great pest in fields of Alfalfa.

Hare's Ear. *Conringia orientalis* (L.) Dumort. Seeds brown, surface checked off into minute irregular pits or patches; broad oval, 2-2.5 mm. long, in section nearly circular, except two opposite slight grooves near one side. Cotyledons incumbent. Introduced, not common.

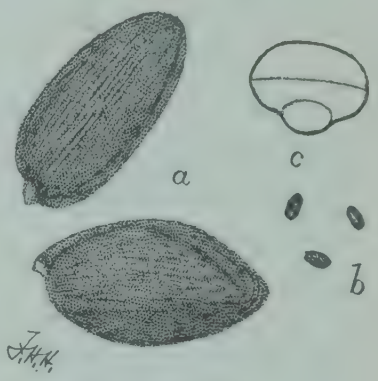


Fig. 88.

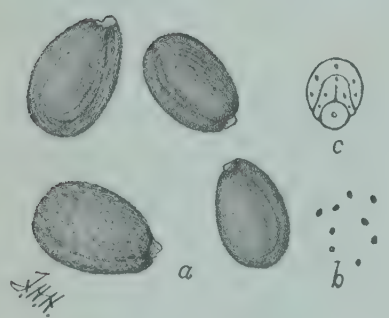


Fig. 89.

Sand Rocket. *Diplotaxis muralis* (L.) DC. Flowers yellow, seeds reddish yellow or reddish brown, broad oval, somewhat flattened. Mucilaginous when wet. Introduced from Europe. A vigorous weed.

Worm-seed or Treacle Mustard. *Erysimum cheiranthoides* L. Flowers yellow; seeds reddish yellow, smooth, dull, about 1.2 mm. long, ovoid or oval, more or less flattened, varying much in shape; some of them acute, rhombic or triangular, becoming mucilaginous when wet. Probably introduced from Europe. If not already in some portions of the state, we may at any time expect to find three other species of Erysimum. A vigorous and prominent weed.

Fig. 90.

Apetalous Pepper-Grass. *Lepidium apetalum* Willd. Petals usually

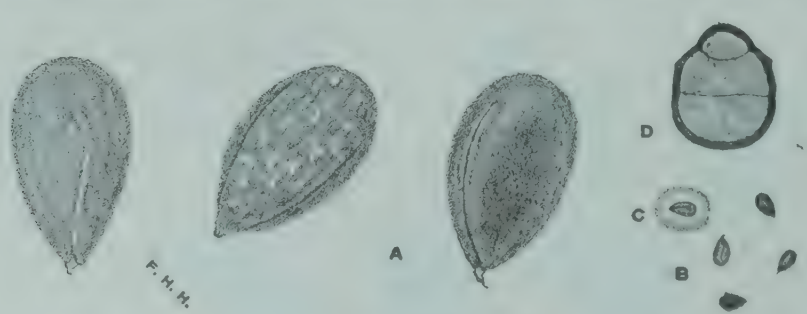


Fig. 91.

wanting, sometimes 2 and minute; pods flat, nearly circular; seeds reddish yellow, flattened, ovate, 1.5-1.8 mm. long, or more exactly, nearly

straight on one side and roundish on the other. Mucilaginous when wet. Cotyledons incumbent. When well developed in open places it becomes a tumble weed. Apparently naturalized from Europe.

Field Pepper-Grass or Cow Cress. *Lepidium campestre* (L.) R. Br. Petals white; pods flat, nearly circular; seeds dull, dark brown, obovoid,

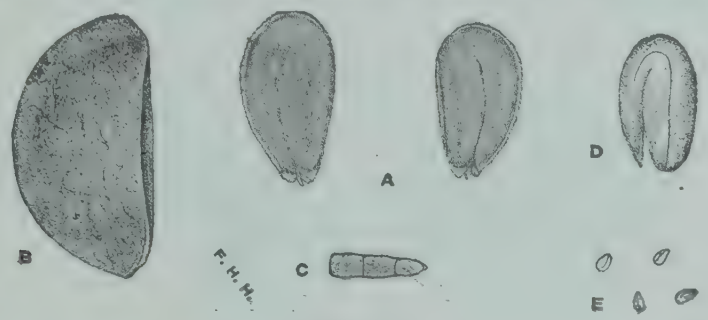
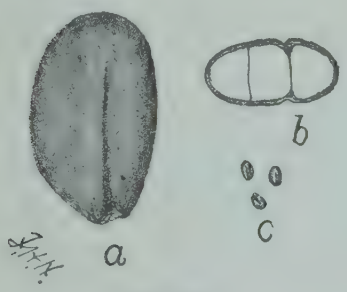


Fig. 92.

with base acute, more or less flattened on three sides, 2-2.5 mm. long. Mucilaginous when wet. Cotyledons incumbent. Naturalized from Europe.



Hoary Cress. *Lepidium Draba* L. Seed reddish brown, surface slightly uneven, slightly flattened, oval to broad oval, 2-2.3 mm. long, usually with two slight vertical grooves on each side, incumbent. This may soon appear in Michigan.

Fig. 93.

Golden Pepper-grass. *Lepidium sativum* L. Seed reddish yellow to reddish brown, oval, slightly compressed, often nearly straight on one edge, usually showing two vertical grooves on each side, 2.5 mm. long, cotyledons incumbent. This is not a grass but a plant of the mustard family; it has escaped from cultivation.

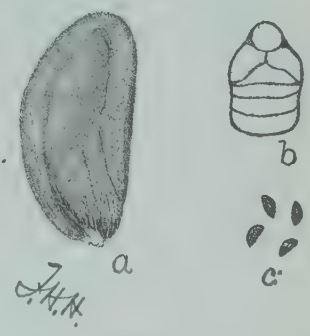


Fig. 94.

Wild Pepper-Grass. *Lepidium Virginicum* L. Petals white, pods flat,

Fig. 95.

nearly circular; seeds granular, dull, reddish yellow, flat, ovoid with one edge straight, the other rounded. usually with a slight wing on

the broad end and on the round edge. 1.5-1.8 mm. long. Mucilaginous when wet. Cotyledons accumbent.

When mature, large plants become tumble weeds. Apparently native to this country.

Ball Mustard. *Neslia paniculata* (L.) Desv. Small fruits, greenish to light yellowish-brown, globular, 2 mm. in diameter, covered with net-

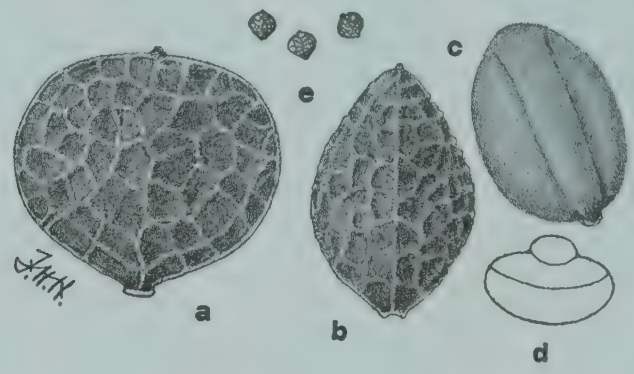


Fig. 96.

veined ridges; 1-2 seeded, cotyledons incumbent. Not yet known in Michigan but may arrive any time. Native of Europe.

Fig. 97.

Tall or Tumbling Mustard. *Sisymbrium altissimum* L. Flowers cream-color; pods long and narrow; seeds reddish yellow, oblong, about 1.5 mm. long, the apex winged. Mucilaginous when wet. Cotyledons incumbent. Introduced from Europe. One of the worst weeds in the northwest.

Hedge Mustard. *Sisymbrium officinale* (L.) Scop. Flowers yellow, seeds reddish brown or yellow, oblong, while lying on the flat side, circular in outline at the middle as viewed from the edge, straight on one side from the middle tapering to each end. 1-1.5 mm. long. Mucilaginous when wet. Cotyledons incumbent. Introduced from Europe.

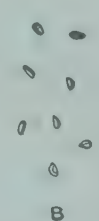


Fig. 98.

Fig. 99.

Penny Cress. *Thlaspi arvense* L. Flowers white; pods thin, double convex, nearly circular; seeds deep reddish brown, flat-oval or ovate, covered on each side by 12-14 curved ridges which originate and terminate at the narrow extremity. 1.5-2 mm. long. Cotyledons accumbent. When eaten by cows the milk and meat has a disagreeable taste. A

ORPINE FAMILY. CRASSULACEAE.

Fig. 100.

Mossy Stonecrop. *Sedum acre* L. Seed light, reddish-yellow, somewhat glossy, obovate to oblong, pointed at the base, slightly anatroupous, compressed, 6-7 mm. long. This mossy little plant is persistent when once established in sandy soil. Introduced from Europe.

ROSE FAMILY. ROSACEAE.

Tall Hairy Agrimony. *Agrimonia crypose-pala* Wahl. *Agrimonia hirsuta* (Muhl.) Bicknell. Flowers yellow. Burr, consisting of calyx and two included fruits inside of which are two seeds; lower part of bur, top-shaped, rough, grooved, above which are numerous hooked prickles in several rows, the whole 7-10 mm. long. Native of woods in this country; seeds mottled brown, flat on one side, 2.5 by 2.5 mm. not found mixed with grass seed. Several other species are nearly as troublesome as this one. Seldom found out of the woods.

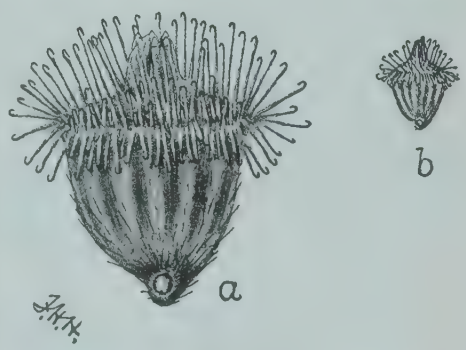


Fig. 101.

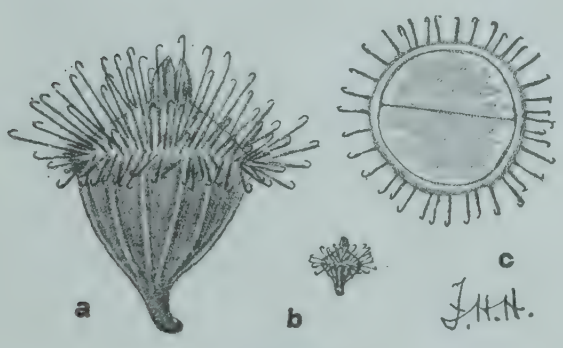


Fig. 102.

Small-flowered Agrimony. *Agrimonia parviflora* Ait. Flowers yellow; fruit 5-6 mm. long and nearly as wide including the hooked bristles; bristles few, erect or spreading, scarcely any recurved; seeds light brown, broad oval, 2.7 by 2.5 mm. with a rounded point at the base more pronounced than in the former species. Shady places.

Silvery Cinquefoil. *Potentilla argentea* L. Flowers yellow, achenes dull white to brown, unsymmetrically ovoid or short kidney-shaped, slightly flattened, 0.5-0.7 mm. long, smooth or marked by a few longitudinal curved ridges, some of them forked. Introduced into Michigan from Europe or possibly from the eastern states. Thrives in sandy land.

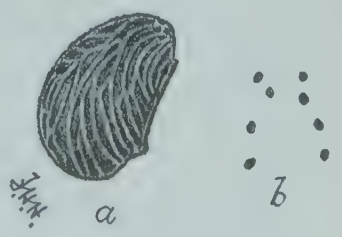


Fig. 103.

One kind of Cinquefoil or Five-finger. *Potentilla Canadensis* L. Achene unsymmetrically ovoid, light straw-color to brown, ridges indistinct, short, wavy, branched and broken up, (these ridges are different from those of P. argentea or P. monspeliensis) 1 mm. long, the achene is less flattened and narrower in proportion. Native from Me. to Ga. Miss.

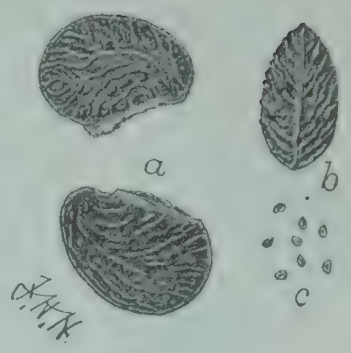


Fig. 104.

Rough Cinquefoil. *Potentilla Monspeliensis* L. Flowers yellow; achenes nearly white to light brown, unsymmetrically ovoid, or short kidney-

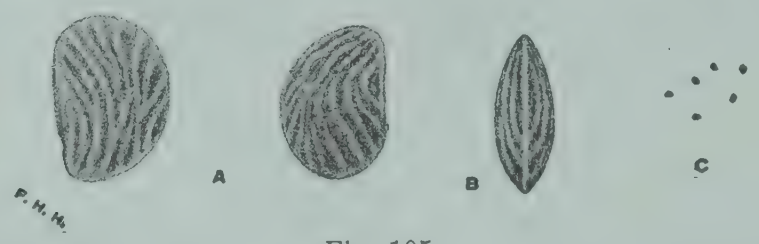


Fig. 105.

shaped, slightly flattened, 1 mm. or less in length, clearly marked by a few longitudinal curved ridges, the longer ones forked. Indigenous to Michigan, thriving on moist or wet land.

PULSE FAMILY. LEGUMINOSAE.

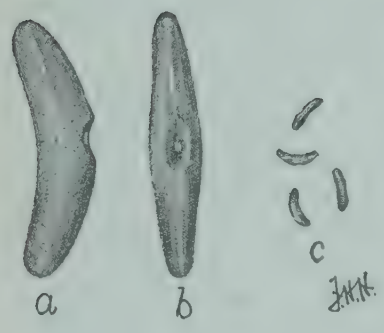


Fig. 106.

Ax Seed. Ax Wort. *Coronilla scoparioides* Koch. Seed reddish brown, oblong, slightly flattened and curved, 4-5 mm. long, 1.5 mm. wide, with a circular scar in a depression on the middle of one edge, and a slight ridge the entire length of both sides. Introduced from Europe, not yet a prominent weed in Michigan.

Bird's-foot Trefoil. Ground Honeysuckle. Bloom-fell. *Lotus corniculatus* L. Seed light brown occasionally mottled with black, shining, spherical to ovoid, slightly compressed near one edge, 1-1.2 mm. in diameter, the compressed portion (raphe) extending half to three-fourths the length of the seed to the hilum or scar, above this the seed is narrower. Introduced from Europe. Seldom met with in this country.

Fig. 107.

Black Medick. Nonesuch. *Medicago lupulina* L. Flowers light yellow; pods black, oval, much flattened, spirally coiled, causing the two extremities to nearly meet; 2-2.8 mm. long; seeds smooth, dull yellow to green,

oval, flattened, kidney-shaped, with a tubercle near the middle of the concave edge or like the figure, 1.5-1.8 mm. long. Introduced from

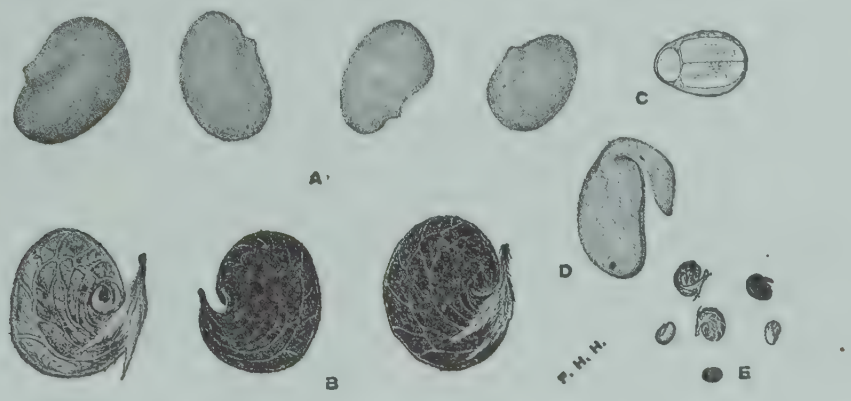


Fig. 108.

Europe and becoming frequent in grass land. Its worst feature is to supply seeds that may be mistaken for and mixed with seeds of alfalfa and red clover. The seeds differ from those of alfalfa in being more commonly egg-shaped than kidney-shaped in outline. The scar is nearer the small extremity in these seeds than in those of alfalfa. For pasture this is less valuable than white clover.

Alfalfa. Lucerne. *Medicago sativa* L. Seeds varying much in shape and size owing to their crowding in the pod when young, yellowish green to light brown. The cuts give a good idea of the variety of shapes; surface dull or somewhat glossy, often kidney shaped, with the scar in a depression near the middle, the tips may be truncate or acute or rounded, 2-2.5 mm. long in cross-section, oval; when viewed from one edge it is seen to be bent or warped in various ways, half anatropous, often seen with a slight depression extending along one edge from the scar to one end, larger seeds more often flattened than are the shorter. A prominent forage plant, the seeds of which are often adulterated. Native of Europe.

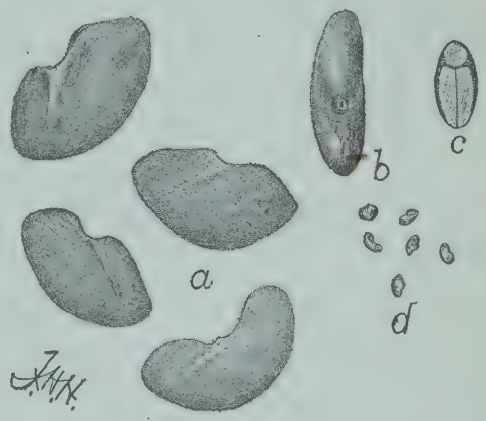


Fig. 109.

White Sweet Clover. *Melilotus alba Desv.* Flowers white; pods straw-

Fig. 110.

color to brown, coarsely and irregularly reticulate-ridged or wrinkled;

seeds smooth, dull, yellowish or greenish, more strictly elliptical-oblong in outline than those of red clover and alfalfa, bearing the broad, shallow notch near one extremity; 2-2.2 mm. long. Introduced from Europe. Seeds used to adulterate those of alfalfa.

Alsike Clover. *Trifolium hybridum* L. Seeds dull yellowish green to very dark green, some of them mottled, lighter about the seed scar, flattened, one of the rounded edges thicker than the other, and between the two a slight groove on each side; seed rounded at one end, the other truncate with the seed scar in the middle of the truncate end. Some seeds are half anatropous, resembling in shape those of red clover; 1.3-1.2 mm. in diameter. When compared with white clover, these seeds are larger and thicker. Introduced from Europe.

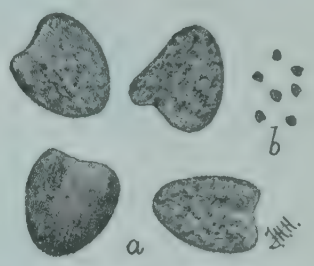


Fig. 111.

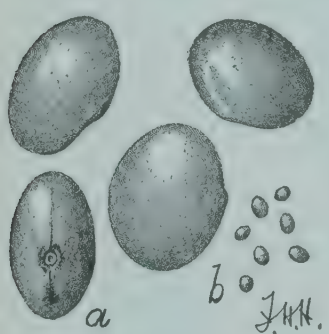


Fig. 112.

Crimson Clover. Scarlet Clover. *Trifolium incarnatum* L. Seed smooth, shining when not old, color light yellow to reddish yellow or brown, oval, scar about one-third the distance from the narrow end, three-fourths anatropous, 2-2.5 mm. long, very slightly compressed.

Red Clover. *Trifolium pratense* L. Seeds usually dull, pure light yellow to purple, flattened, ovoid, having the seed scar near the middle of one edge or below the middle, half anatropous, a slight depression on each side from the scar toward the broad end, the short edge thinner than the long edge, 1.5-1.8 mm. long by 1.x1.4 mm. wide. Very common. Introduced from Europe.

Fig. 113.

Mammoth Clover is a variety or race or red clover, the seeds of which are indistinguishable from the seeds of red clover. As a rule they are darker in color and rather smaller. Red clover and mammoth clover are usually much mixed.

Fig. 114.

Low Hop-clover. *Trifolium procumbens* L. A low, yellow-flowered annual, often becoming a tumble-weed at maturity. Seeds plump, shining, straw-colored to light brown, broad oval, very slightly flattened, 1 mm. long, three-fourths anatropous, i. e., the scar is a very little distance from one end of the seed. A little way back of the scar on each side is a light-colored depression. Rather rapidly spreading. From Europe.

Fig. 115.

White Clover. *Trifolium repens* L. Seeds scarcely shining, yellow to light brown, flattened, one of the rounded edges thinner than the other, and between the two a slight groove on each side, one end rounded, the other truncate with a slight depression in the center containing the seed scar 1.-1.2 mm. long to 1 mm. wide. The seeds that are truncate at one end are anatropous, some of them resembling those of red clover are half anathropous. Common and well known, possibly native to the northern country.

GERANIUM FAMILY. GERANIACEAE.

Alfilaria. Storks-bill. *Erodium cicutarium* (L.) L'Her. Flowers pink; achenes reddish brown, hairy, lance-shaped, the smaller end curved, hard, sharp, the larger end when mature bearing an awn spirally coiled for half its length, the sickle-like apex turned to one side.

Achenes 5-6 mm. long, the coiled portion and cycle-like apex each 10-15 mm. long. True seed light brown, ovoid-lanceolate 2.5-2.7 mm. long. Introduced from Europe.

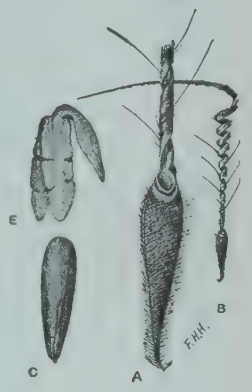


Fig. 116.

This plant is not yet common in our state, but, judging from its behavior in the botanic garden, it is destined soon to become a bad weed. On the desert ranches of Arizona, Nevada and elsewhere, it furnishes much pasture.

Fig. 117.

Cut-leaved Crane's bill. *Geranium dissectum* L. Seed light brown, broadly oval or ovoid, surface deeply pitted requiring 25-30 pits to form one row transversely about the surface. Seed scar at the larger end from which extends a slight vertical ridge reaching nearly one-third the length of the seed. Introduced from Europe, becoming common.

Small-flowered Crane's bill. *Geranium pusillum* Burm. f. Flowers minute, pink, pubescent under a lens, slightly compressed, oval with the apex near one side of one end, about 2 mm. long, the beak nearly twice as long; seed reddish brown, smooth, oval, slightly flattened, 1.7-1.9 mm. long. Introduced from Europe, a bad weed when once established.

Fig. 118.

SPURGE FAMILY. EUPHORBIACEAE.

Three-Seeded Mercury. *Acalypha Virginica* L. Seeds 1.3-1.8 mm. long oval or obovoid, dull, light to dark reddish brown or gray, mottled with black spots, surface covered with numerous irregular vertical lines, a ridge (hilum) extending from the pointed end for about one-third the length, continuing to the broad extremity as a dark line (raphe). Native to this country. Moist land.

Fig. 119.

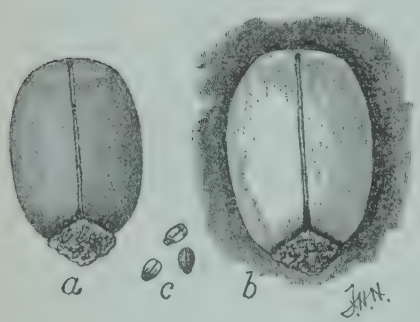


Fig. 120.

Cypress Spurge. *Euphorbia Cyparissias* L. Seeds dull, light lead or ash-colored, oval or oblong, circular in transverse section, 1.5-2 mm. long, not including an irregular yellowish appendage (caruncle) at the base, a dark verticle line (raphe) extending along one side. Introduced from Europe. Thriving on thin sandy soil.

Toothed Spurge. *Euphorbia dentata* Michx. Seeds ash colored, obovoid, or globose, inconspicuously four-angled, base obtuse, irregularly tuberculate, 1 mm. or more long. It thrives in the Botanic Garden and very likely may soon spread onto Michigan farms.

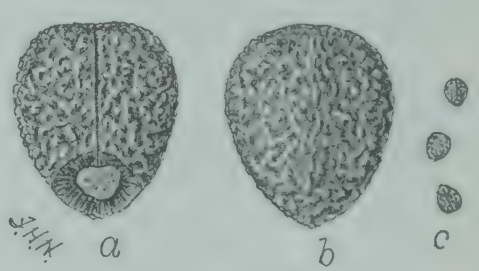


Fig. 121.

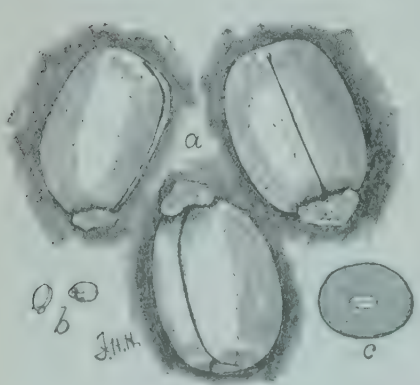


Fig. 122.

Leafy Spurge. *Euphorbia Esula* L. Seeds dull, light drab colored, broad-oval, narrowed at one end, nearly circular in transverse section, 2.3 mm. long, not including a wrinkled bunch (caruncle) at the base, a dark vertical line (raphe) extending above one side opposite which is another ridge the color of the seed. Introduced from Europe.

Fig. 123.

Euphorbia hirsuta (Torr). Weigand. Seeds lead colored, obovoid approximately square in transverse section with one side narrower than the others, 4-10 irregular transverse ridges on each side, the raphe standing along one corner, about 1.2 mm. long by 7 mm. wide. Sandy soil.

Fig. 124.

Spotted Spurge. *Euphorbia maculata* L. Seeds obovoid-oblong, nearly square in cross-sections, minutely pitted and transversely wrinkled with 2-5 broken wavy ridges, a fine dark vertical line (raphe) along one corner, color reddish drab, .6-.8 mm. long. Probably introduced from west of the Rocky Mountains.

Upright Spotted Spurge. *Euphorbia Preslii* Guss. *Euphorbia nutans Lag.* Seeds lead-colored obovoid-oblong, with 4 unequal sides as seen in

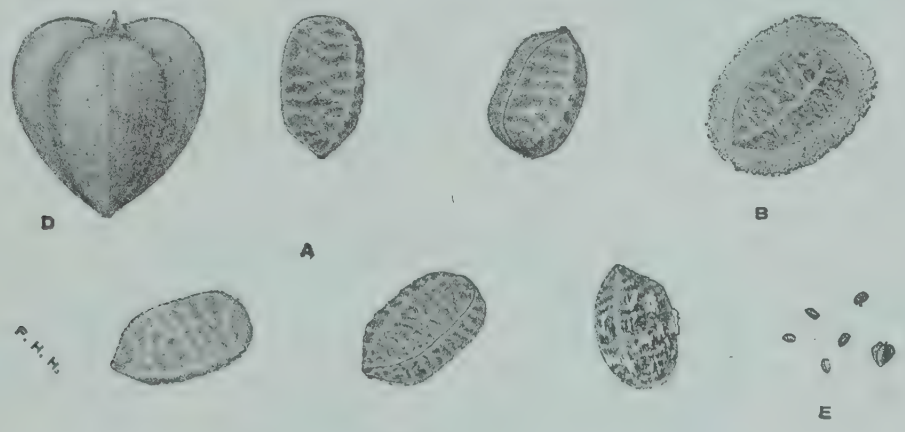


Fig. 125.

cross-section, pitted and transversely wrinkled, with 2-5 broken wavy ridges, a fine dark, verticle line (raphe) along one corner, 1-1.3 mm. long. Native of eastern North America. Introduced in seeds of red clover.

Fig. 126.

Thyme-leaved Spurge. *Euphorbia serpyllifolia* Pers. Seed ash-colored, obovoid, four-angled or nearly square in cross-section, the surface covered with four or five more or less broken obtuse transverse ridges, a slender, dark line (raphe) extending from end to end on one corner. Dry soils, like railway tracks.

CASHEW FAMILY. ANACARDIACEAE.

Fig. 127.

Poison Ivy. *Rhus Toxicodendron* L. Berry nearly white, globular, about 5 mm. in diameter, drupe kidney-shaped, concave on both edges, 3 by 4.5 mm. in diameter, 2 mm. thick. To some people very poisonous to the touch; a woody shrub.

MALLOW FAMILY. MALVACEAE.

Indian Mallow. American Jute. Velvet Leaf. *Abutilon Theophrasti* Medic. *Abutilon Abutilon* (L.) *Rusby.* Flowers yellow; seeds brown,

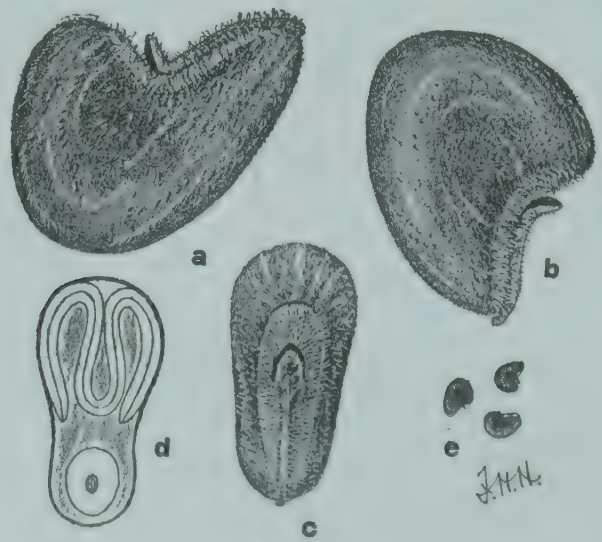


Fig. 128.

flattened, 3.5-4 mm. long, ovoid excepting a piece cut from one side of the smaller end with 3-4 curved rows of minute slender objects on each side, the raphe extending from the pointed end to the notch on one side (half anatropous). Naturalized from northern Asia.

Fig. 129.

Bladder Ketmia, *Hibiscus Trionum* L. Seed brown, the surface dotted with numerous, ragged, light-colored pimples. Think of the shape as obovoid, and then bent somewhat to the side. As now found the seed is triangular in outline with rounded corners, considerably thinned toward one corner near which is the seed scar in the midst of a depression. Each side of the triangle is about 2 mm. long. Introduced from Europe. Not yet a prominent weed in Michigan.

Cheeses. Running Mallow. *Malva rotundifolia* L. Flowers white; cluster of 12-15 fruits flattened, circular with depression on each side, ovary circular, wedge-shaped, very slightly roughened, with radiating

Fig. 130.

ridges; seeds light brown, nearly smooth, flattened, 1.4-1.7 mm. in diameter, wedge shaped, nearly circular with a small notch on the thin edge. Naturalized from Europe.

Whorled Mallow. *Malva verticillata.* L. Flowers white; cluster of 10-12 fruits flattened, circular with depression on each side, carpel circular, wedge-shaped, about three rows of irregular shallow pits on the wide edge, radiating ridges on each flat side; seeds light brown, nearly smooth, flattened, wedge-shaped, ovate or nearly circular, 1.5-1.7 mm. long, with a small notch on the thin edge. Introduced from the west.

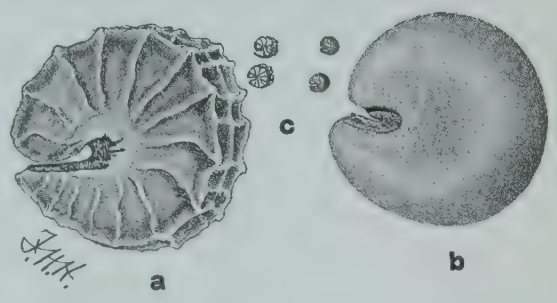


Fig. 131.

Fig. 132.

Prickly Sida. *Sida spinosa* L. Seed smooth, dull brown or reddish brown, having one side round and two sides flat or more or less concave, all edges obtuse while lying on one flat side, broadly ovoid, with one side nearly straight, scar at the larger end in the midst of a slight depression, 1.5-1.8 mm. long. Not yet common in Michigan. Introduced from the tropics.

ST JOHN'S-WORT FAMILY. HYPEPICACEAE.

Common St. John's-wort. *Hypericum perforatum* L. Seed dark brown, mottled with about twenty-four vertical rows of small scars, short oblong, 1 mm. long, a little more or less, circular in cross-section, a slight point at one or both ends. Troublesome in old meadows and pastures. From Europe.

Fig. 133.

EVENING-PRIMROSE FAMILY. ONAGRACEAE.

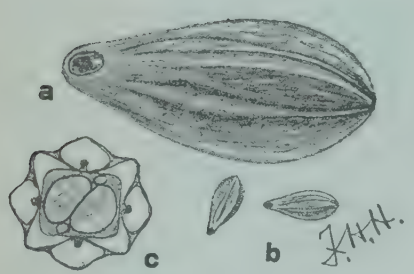


Fig. 134.

Small-flowered Gaura. *Gaura parviflora* Dougl. Achenes greenish brown, at first glance, having the appearance of barley, linear, swollen in the middle, more or less grooved or channeled, 6-8 mm. long. Introduced from the South.

Common Evening-Primrose. *Oenothera biennis* L. *Onagra biennis* (L.) Scop. Flowers yellow; seeds reddish brown or darker, surface dull,

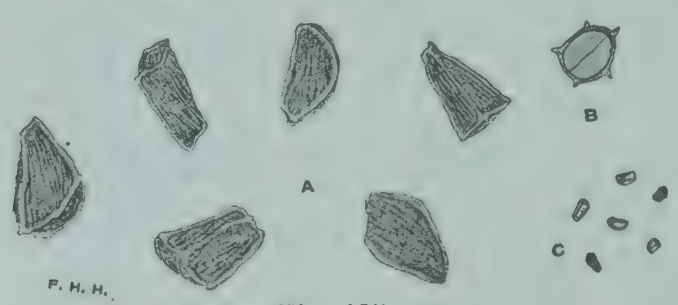


Fig. 135.

minutely ridged, very irregular in shape owing to crowding in the pod, more or less pyramidal and four or five sided, the angles acute or with a wing-like border, 1.-1.5 mm. long. Native to this country.

PARSLEY FAMILY. UMBELLIFERAE.

Water Hemlock. Mosquash Root. Beaver Poison. *Cicuta maculata* L. Achenes, when young grow in couples joined by their flat sides, broadly oval, somewhat flattened, a single one-half oval, 2.7-3.2 mm long, with

Fig. 136.

five corky yellowish white vertical stripes alternating with four brown oil tubes, the flat side with two wide light corky stripes including two brown oil tubes. The roots are very poisonous. Native to Michigan and elsewhere. Moist or wet lands.

Poison Hemlock. *Conium maculatum,* L. Flowers white, achenes growing in pairs, light brown, oval, flat on one side, five ribs extending

Fig. 137.

from one end to the other, between them the surface abounds in minute vertical projections, achene about 3.5 mm. long. Difficult to identify Introduced from Europe.

Wild Carrot. *Daucus Carota* L. Flowers white; achenes light brown,

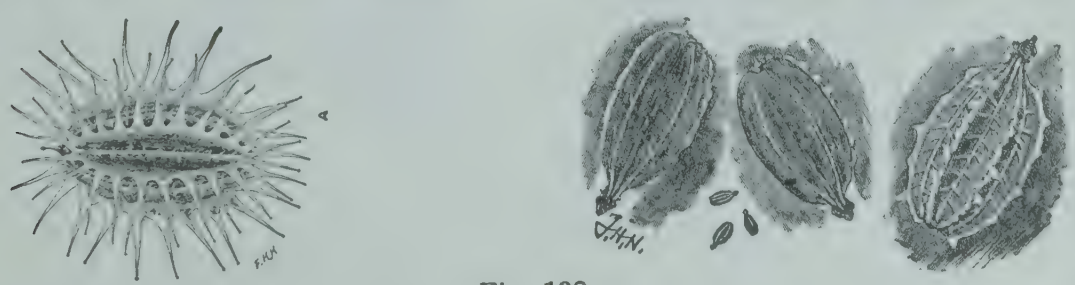


Fig. 138.

striped with white, oval, flattened, bearing numerous frail spines along

the edges and in two rows lengthwise of one face, tips of spines diverging, often hooked, about 3.5 mm. long not including the spines. Introduced from Europe. This is the cultivated carrot escaped from fields and gardens. A great pest in old meadows.

Wild Parsnip. *Pastinaca sativa* L. Flowers yellow; achenes growing in pairs, 5-6 mm. long, with flat sides together, light brown, broad oval, much flattened, surrounded by a narrow thin ridge, 9-curved shallow ribs on one side. Introduced from Europe.

Fig. 139.

MILKWEED FAMILY. ASCLEPIADACEAE.

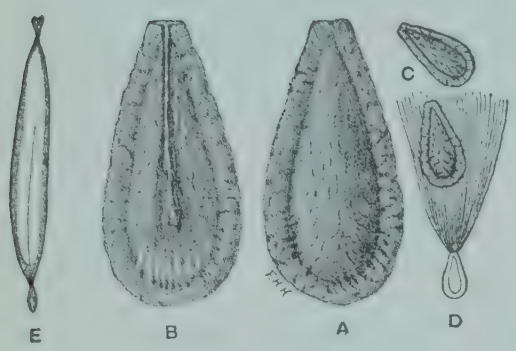


Fig. 140.

Common Milkweed. *Asclepias Syriaca* L. Pods 8-12 cm. long, covered with soft spiny processes; seeds dull light brown, much flattened, narrowly obovate, 6.5-8 mm. long, the small end truncate, surrounded by a broad wrinkled wing-margin or hem. The concave side bears a slender vertical ridge (raphe) for two-thirds of its length; the convex side bearing fine, short ridges. Before escaping from the pods, the small end of the seed contains a cluster of spreading silky hairs (coma) 2-3 cm. long. Native of this country. Often troublesome and conspicuous in light soil, occasionally becoming small, pale, with slender branches and dying.

Black Swallow-wort. *Cynanchum nigrum* (L.) Pers. *Vincetoxicum nigrum* Moench. Smooth pods of the vine about 5 cm. long; seeds brown when dry, much flattened, concave, obovate, 6-8 mm. long, nearly surrounded by a wing margin or hem, the small end truncate. The concave side bears a slender vertical ridge (raphe) for over half its length, both sides bearing fine short ridges. Before escaping from the pods, the small end of the seed contains a cluster of spreading silky hairs. Introduced from Europe; not yet common, but it is persistent where once started.

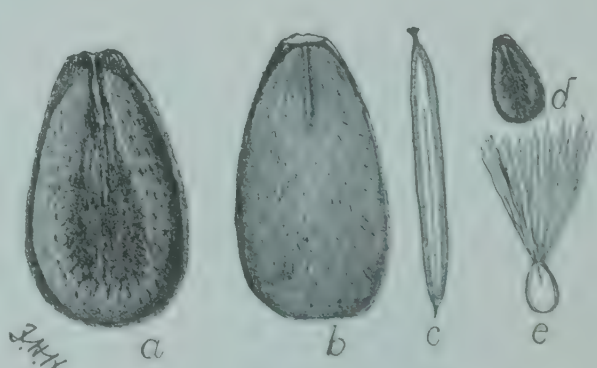


Fig. 141.

MORNING GLORY FAMILY. CONVOLVULACEAE.

Fig. 142.

Small Bindweed. *Convolvoulus arvensis* L. Color of seeds dull dark brown, coarsely roughened, oval, 3-4 mm. long, one face convex, the other face sloping to the edges from a broad, central ridge, becoming mucilaginous when soaked in water. Introduced from Europe. Seldom, if ever, seeding in Michigan. On dry, poor land.

Hedge or Great Bindweed. *Convolvulus sepium* L. Pod nearly globose, about 8 mm. in diameter, usually covered by the bracts and calyx; seeds dull black or dark brown, roughened, oval, about 5 mm. long, one face convex, the other face sloping to the edges from a central ridge. Native to this country. Seldom seeding in Michigan. On low land.

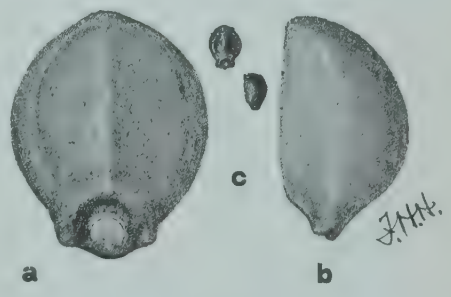


Fig. 143.

Fig. 144.

Field Dodder. *Cuscuta arvensis* Beyrich. A pale yellow leafless parasitic vine; seeds dull, yellowish brown, minutely pitted, considerably resembling those of red clover, broad oval, ovoid or spherical, .7-1 mm. long, one side rounded the other often with two flat surfaces terminating in a ridge. Not uncommon with alfalfa.

Flax Dodder. *Cuscuta Epilinum* Weihe. Stems very slender, yellow or red, a parasitic vine; seeds dull, yellowish to dark brown, minutely pitted, nearly spherical, oval, ovoid, 1-1.5 mm. long. Introduced from Europe.

Fig. 145.

Clover Dodder. *Cuscuta Epithymum* Murr. Stems very slender, a parasitic vine; seeds oval to spherical, dull, pitted, color yellowish, light

Fig. 146.

to dark brown, light green to purple, about 2 mm. long. Introduced from Europe. Occasionally found on red clover.

Gronovius Dodder. *Cuscuta Gronovii* Willd. Seed light to dark brown, surface minutely granular, free from gloss, a few spherical, most of them indented as they dry or variously angled where they crowded against each other in the pod, 1.5-1.7 mm. in diameter.

Fig. 147.

Species of dodder are difficult to distinguish one from the other. This is common on low land, where it draws nourishment from a great variety of plants, such as willows, balsams, nettles.

Fig. 148.

Spanish Dodder. *Cuscuta planiflora* Tenore. Color light to dark pink, purple buff, olive green; surface well roughened, almost reticulated, in shape flattened on one side, ovoid, oval angled, indented in great variety 0.7-1.2 mm. long.

BORAGE FAMILY. BORAGINACEAE.

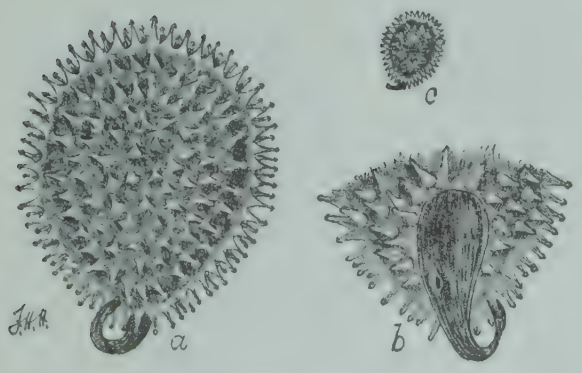


Fig. 149.

Hound's Tongue. *Cynoglossum officinale* L. Flowers reddish purple; ovary brown deeply 4-lobed separating into four achenes, 5-7 mm. long, flattened, broadly ovate or circular, excepting a slight extension at one end, lower side having an ovate scar, nearly half as long as the achenes, all the rest of the surface clothed with straight, stiff, cap-shaped hairs, bearded on all sides. Introduced from Europe. Very objectionable in pastures.

Stick-Seed. Burr Seed. *Lappula echinata* Gilibert. *Lappula Lappula* (L.) Karst. Flowers blue, ovary deeply 4-lobed separating into four warty achenes, each one brown, about 2.5 mm. long, slightly flattened, ovate with wedge-shaped apex; the upper side bearing a few stiff straight, diverging cap-shaped hairs, bearded on all sides; lower side destitute of hairs, bearing a straight ridge from the point to the middle of the large end. Introduced from Europe. Very objectionable in pastures.

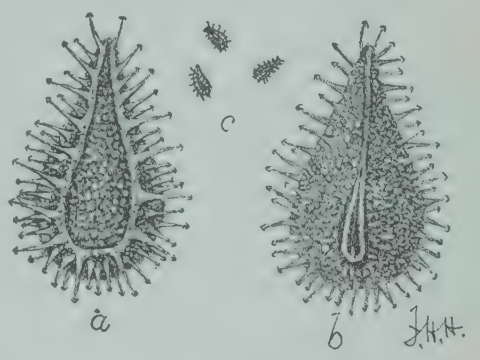


Fig. 150.

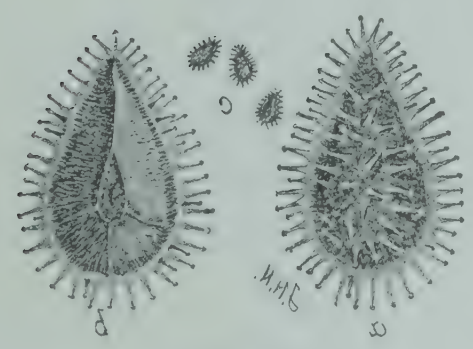


Fig. 151.

Wild Comfrey. *Lappula Virginiana* (L.) Greene. Flowers blue; ovary deeply 4-lobed separating into four brown achenes, about 3 mm. long, flattened on upper side, broadly ovate, the apex wedge-shaped, the upper side clothed with stiff straight cap-shaped hairs, bearded on all sides; lower side a low 4-sided cone, nearly smooth with a concave triangular scar. Native to rich woodlands.

Red Root. Wheat Thief. Corn Gromwell. *Lithospermum arvense* L. Flowers white; ovary 4-divided separating into four hard, connical-

Fig. 152.

ovoid achenes, each dull gray, erect, wrinkled, 2.5-3 mm. long, convex on the back, keeled on the inner side, base obliquely truncate, containing two minute white tubercles. A prominent weed of high rank in fields of winter wheat.

VERVAIN FAMILY. VERBENACEAE.

Blue Vervain. *Verbena hastata* L. Achenes crowded, four together until mature, dull, reddish brown, flattened, oblong, 1.7-2 mm. long, bordred by a narrow margin, the outer face convex, bearing 3-5 small vertical ridges branching and uniting at the apex, forming a distinct network, the inner face sloping to the margin from a central vertical ridge; a light colored scar is seen on one side of the base. Native to this country. Not important.

Fig. 153.

Fig. 154.

Nettle-leaved Vervain. *Verbena urticifolia* L. Achenes 1.6-1.8 mm. long, very closely resembling the last above mentioned. The achenes of this one are a trifle shorter and broader, more nearly oval than oblong. Native to this country. Not common in fields.

MINT FAMILY. LABIATAE.

Fig. 155.

Dead Nettle. *Lamium amplexicaule* L. Achenes light brown, conspicuously marked by white spots some of which coalesce making the surface striped crosswise, obovate-oblong, pointed at the smaller end, 1.5-2 mm. long, the outer surface rounded, the inner face angled, the concave surfaces sloping to the edges from a central vertical ridge. Introduced from Europe. Thrives in cool weather.

Motherwort. *Leonurus Cardiaca* L. Achenes light brown, obovoid-oblong, rounded on one side flat on the other two sides, the truncate apex hairy, 2-2.4 mm. long. Introduced from Europe. Waste places.

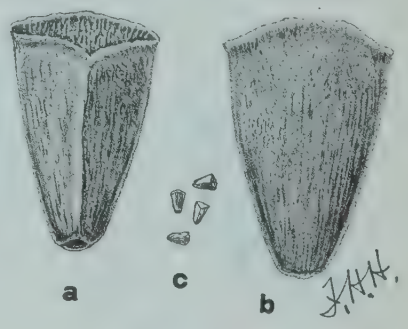


Fig. 156.

Fig. 157.

White Hoarhound. *Marubium vulgare* L. Achenes dull, varying from light to dark brown, sometimes finely roughened by numerous minute tubercles, slightly flattened, oval or obovoid, about 2 mm. long, outer surface convex, inner face angled sloping to the edges from a central vertical ridge, edges of achenes often slightly margined, surface lightly grooved. Introduced from Europe. A weed in northern Michigan where snow protects it in winter.

Catnip. Catmint. *Nepeta Cataria* L. Achenes dull, light reddish brown to nearly black, with two laterally placed cavities near the base,

Fig. 158.

each filled with white spongey tissue, broadly oval, slightly flattened, 1.3-1.7 mm. long. Introduced from Europe. Scarcely a weed.

Self-heal. Heal-all. *Prunella vulgaris* L. Achenes light to dark brown, slightly roughened, having a diffused luster, slightly flattened, oval or oblong, the base tapering to a small whitish, triangular appendage, outer side convex having dark verticle lines, the other face sloping to the edges from a central ridge, becoming mucilaginous when soaked in water. Native to this country.

Fig. 159.

NIGHT SHADE FAMILY. SOLANACEAE.

Fig. 160.

Jimson Weed. Thorn-apple. *Datura Stramonium* L. Pods ovoid, densely prickly, about 4 cm. long; seeds black to brown, flattened, with 6-10 slight irregular elevations, the whole surface covered with minute shallow pits, short kidney shaped, i. e., one edge nearly straight or slightly notched, the remainder of the margin making about two-thirds of a circle. 3-3.5 mm. long. Most likely introduced from Asia. A coarse, poisonous weed found in waste places.

Purple Jimson Weed. Purple Thorn-apple. *Datura Tatula.* The color of the stems are purple, the flowers and pods nearly the same as those last above; seeds of the two scarcely if at all unlike. Naturalized from tropical America. Waste places.

Fig. 161.

Fig. 162.

Horse Nettle. *Solanum Carolinense* L. Berry orange-yellow, 1.6 to 2 cm. in diameter; seeds lemon yellow, slightly double convex, obovate 2.1-2.9 mm. long, surface finely granular all over. Native of the southwest U. S. It spreads rapidly by long roots.

Fig. 163.

Black Nightshade. *Solanum nigrum* L. Berry black, smooth, globose, 8-10 mm. in diameter; seeds finely granular, dull, yellowish to light grown, flattened, unsymmetrically ovate, about 1.5 mm. long. Native to this country. I have the best of authority for saying that these berries when ripe make good pies, whether the uncooked fruit is poisonous there is less proof. Of little importance.

Beaked Nightshade. *Solanum rostratum* Dunal. Fruit surrounded by a persistent prickly calyx about 2 cm. long; seeds flattened, irregularly undulate or wrinkled, dark brown or black, usually ovate or circular in outline, 2-2.5 mm. in diameter, surface covered with small pits. Introduced into Michigan from the southwest. A coarse prickly weed.

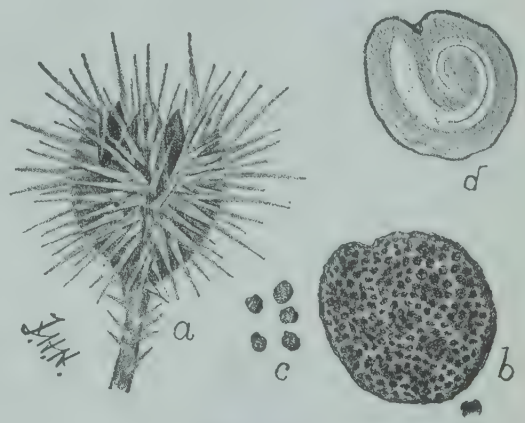


Fig. 164.

FIGWORT FAMILY. SCROPHULARIACEAE.

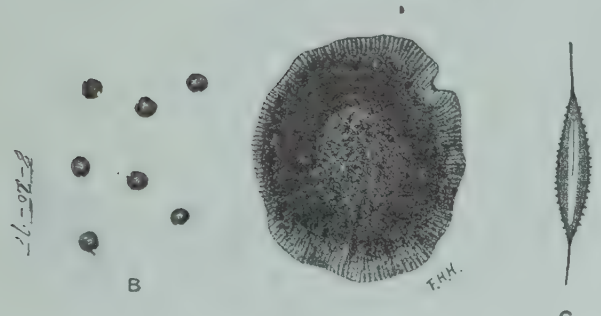


Fig. 165.

Butter and Eggs. Toad-Flax. *Linaria vulgaris* Hill. *Linaria Linaria* (L.) Karst. Flowers yellow and orange; seeds dark brown or black, flat, circular or oval, surrounded by a broad wing-margin, the wing notched and covered by numerous fine radiating ridges, the surface of the seed roughened by numerous projecting points, seed, including its wing, 1.5-2 mm. long. Introduced from Europe. A vigorous weed in meadows, spreading by seeds and by root stocks.

Moth Mullein. *Verbascum Blattaria* L. Flowers yellow; pod 6 mm. diameter; seeds light to dark brown, .5-1 mm. long, columnar, lateral surface slightly angular and 6-sided, base truncate or obliquely so and broader than the rounded apex, thus somewhat thimble-shaped, each lateral face deeply pitted in longitudinal rows, the pits in contiguous rows, alternating. Introduced from Europe. A vile weed in meadows and pastures.

Fig. 166.

Velvet-Leaved Mullein. *Verbascum Thapsus* L. Flowers yellow; pod 6 mm. high; seeds cannot be distinguished with certainity by means of the ordinary lens from those of moth mullein. The pitted surface seems to predominate in *Verbascum Blattaria,* while the grooved surface seems to be more common in the seeds of V. Thapsus. Introduced from Europe. Common in thin pastures.

Wall Speedwell. *Veronica arvensis* L. Pods heart-shaped; seeds dull, light yellow, flattened, oval, .7-1.1 mm. long on one side appearing as though the two ends had been brought together by bending. From Europe.

Fig. 167.

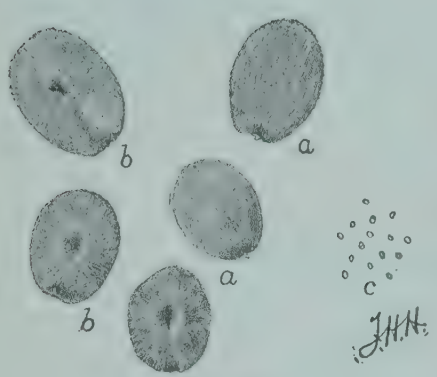


Fig. 168.

Common Speedwell. *Veronica officinalis* L. Pods heart-shaped; seeds dull, pale yellow, flattened, broadly oval to broadly obvate, .8-1.2 mm. long, with a small scar near the middle of one side, from which extends a faint line (raphe) to one extremity. Appearing as though introduced.

Purselane Speedwell. *Veronica peregrina* L. Pods heart-shaped; seeds dull, light reddish yellow, flattened, oval to broadly obovate .5-.8 mm. long, with a small scar a little above the middle of one side, from which extends a dark line (raphe) to one extremity. Most likely native to this country.

Fig. 169.

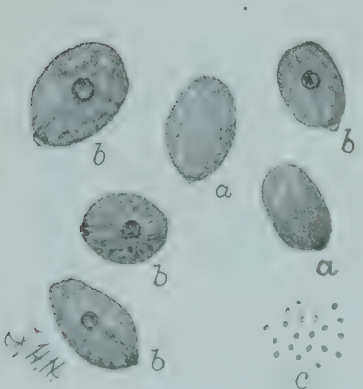


Fig. 170.

Thyme-leaved Speedwell. *Veronica serpyllifolia* L. Pods broadly heart-shaped; seeds pale yellow, a trifle darker than those of V. officinalis, light, reddish yellow, in shape and markings much like those of V. peregrina, flattened, broadly oval to obovate .5-.7 mm. long, with a small scar near the middle on one side, from which extends a dark line (raphe) to one extremity.

Apparently native to this country.

Seeds of the Veronicas are very difficult to distinguish from one another.

PLANTAIN FAMILY. PLANTAGINACEAE.

Sand Plantain. *Plantago arenaria* W. & K. Seeds dark amber brown, shining, rounded on the back like the bottom of a shallow canoe, 2.5-3 mm. long, transverse groove around the middle of the back, opposite side with a groove extending lengthwise, about as wide as the ridge on either side of it; hilum in the middle of the groove. Found at Harrisville, Mich.

Fig. 171.

Large-bracted Plantain. *Plantago aristata* Michx. Seeds oval, dull, light to dark brown, 2.2-3 mm. long, shaped like a shallow, thick-walled canoe with ends rounded alike, outer face marked by a shallow, trans-

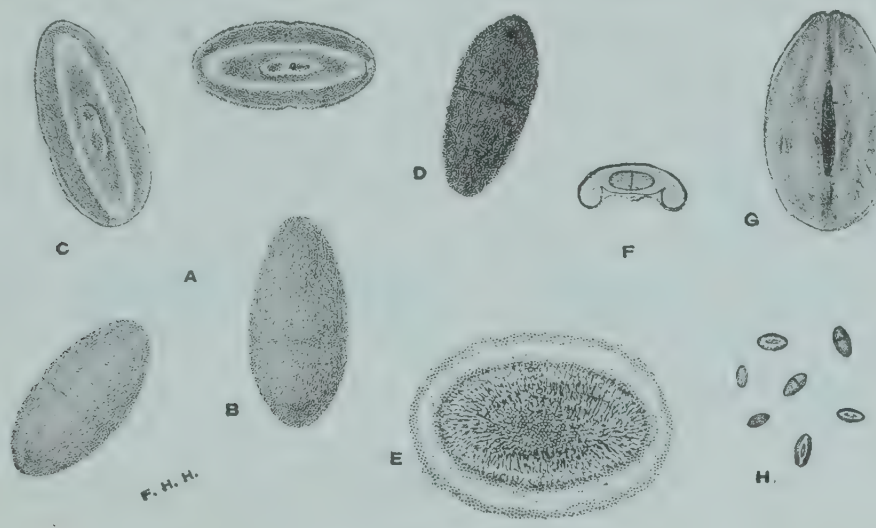


Fig. 172.

verse groove at or near the middle, a white line marking the margin at the base on the canoe inside, two white-margined pits occupying the middle of the concave side. Introduced from the west in clover seeds, not yet common.

Rib-Grass. **Narrow-leaved Plantain.** *Plantago lanceolata* L. Seeds shin-

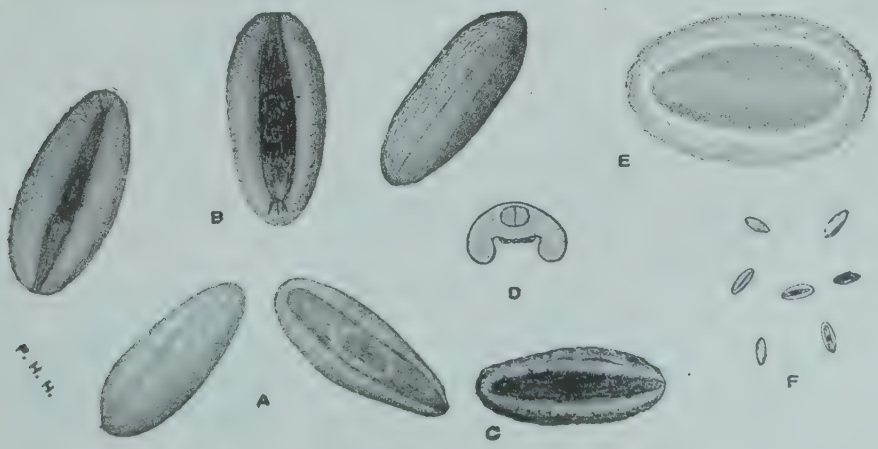


Fig. 173.

ing, amber-colored to brown, oval, 2-2.5 mm. long, shaped like a shallow, thick-walled canoe with ends rounded alike, a dark scar occupying the

middle of the narrow concave side, a faint, transverse groove across the convex side near the middle sometimes apparent. Often found mixed with clover seeds from which it is very difficult to separate. Introduced from Europe.

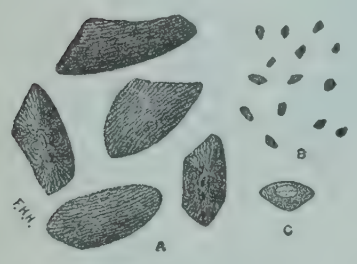


Fig. 174.

Broad-leaved Plantain. *Plantago major* L. Seeds, light to dark brown or very nearly black, 1-1.5 mm. long, slightly flattened, with acute edges very variable in shape, oval, oblong, rhombodial and trapezoid, the surface roughened by slender, colored ridges, appearing under the lens as slightly wavy lines, radiating from the scar. The clear light green color of the lower end of the leaf-stem is an easy mark to distinguish this plant from another broad-leaved plantain, *P. Rugelii* in which the base of leaf is red. Introduced from Europe. About door yards.

Rugel's Broad-leaved Plantain. *Plantago Rugelii Decne.* Seeds dark brown to black, much like those of P. major, but larger, 1.5-2.5 mm. long slightly flattened, with edges acute, very variable in shape, oval

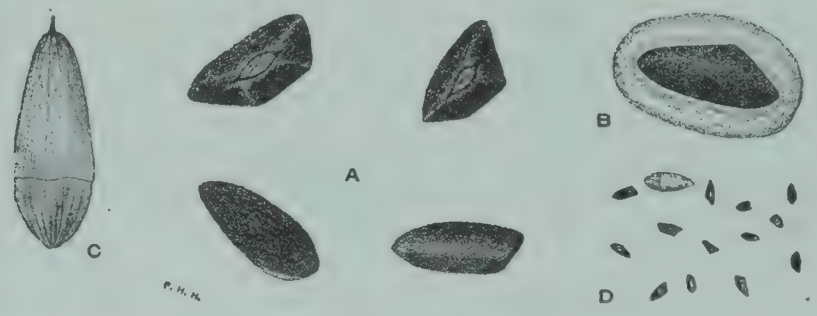


Fig. 175.

oblong, rhomboidal, surface minutely roughened and dull, but wholly without ridge or lines as in P. major. Native of this country. Lower end of leaf-stalk red, and not clear green as in P. major. A vile pest in clover fields.

MADDER FAMILY.

Blue Field Madder. *Sherardia arvensis* L. The parts often called seeds are in reality the half-fruits ripened, each one bearing at the apex three, white, pointed, persistent calyx lobes, the inner face showing a vertical groove, and in some of the fruits the calyx is broken off. Surface dull brown, clothed with small white hairs, obovoid, 2-2.5 mm. long. Introduced from Europe, not often found in the northern states.

Fig. 176.

TEASEL FAMILY. DIPSACAEAE.

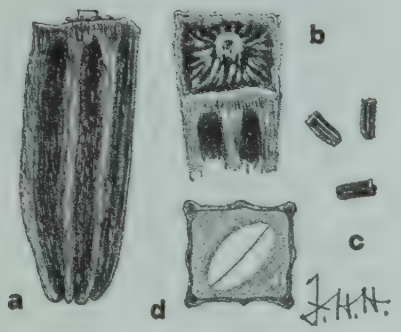


Fig. 177.

Wild Teasel. *Dipsacus sylvestris* Huds. Achene brown, minutely hairy, 4 mm. long, oblong, square in cross-section, with four vertical ribs on the angles and four on the sides. Seed suspended, anatropous supplied with endosperm. Introduced from Europe. A weed requiring two years from seed to seeding.

COMPOSITE FAMILY. COMPOSITAE.

Yarrow. Milfoil. *Achillea Millefolium* L. Flowers white; achenes white to gray, finely striate lengthwise, flattened, oblong, tapering at the lower end, straight or curved. 2-2.3 long. Most likely introduced from Europe.

Fig. 178.

Ragweed. *Ambrosia artemisiifolia* L. Achenes hard, straw-colored to light brown or black, top-shaped, broadly oval, 2.5-3 mm. long, besides

Fig. 179.

the beak 1.5 mm. long, the sides irregularly ridged vertically, with 5-10 short teeth at the apex. Sometimes the hard covering is removed by a clover huller, exposing the naked seed. Native of the U. S.

Great Ragweed. *Ambrosia trifida* L. Achenes hard, brown, more or less mottled, top-shaped, 7-8 mm. besides the stout beak 2-3 mm. long, sides with 5 stout ridges terminating in 5 short teeth. Native to the United States. River bottoms, low land, sometimes 15 ft. high.

Fig. 180.

Corn Camomile, *Anthemis arvensis* L. Achenes very variable, creamy white to light brown, oblong, wedge-shaped in outline, circular to four-angled in cross-section, more or less ribbed lengthwise, a ripple-shaped

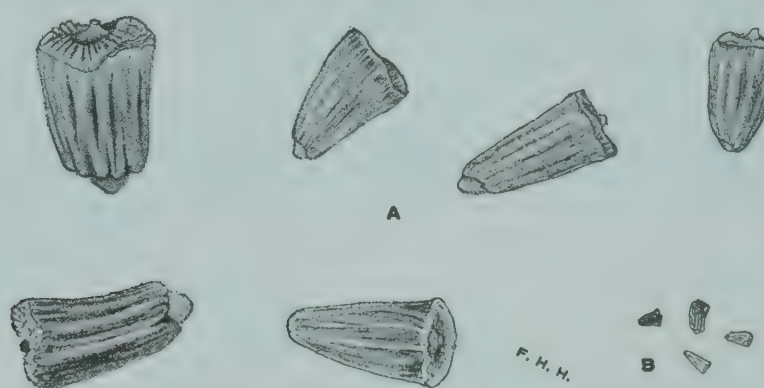


Fig. 181.

scar at the narrow end; apex truncate with a minute projection in the center, often with a narrow ridge about the margin. About 1.7 mm. long. Introduced from Europe. Seldom troublesome in Michigan.

May-weed. Dog's-Fennel. *Anthemis Cotula* L. Outer flowers white; achenes straw color to light brown, obovoid (large end uppermost) to oblong, circular in outline, 1.3-1.8 mm. long, with 10 warty ribs. Introduced from Europe. Old roads and waste places.

Fig. 182.

Fig. 183.

Great Burdock. *Arctium Lappa.* So far as I have seen the achenes of this species, when compared with A. minus, are darker colored, rather longer, the ribs more distinct.

Smaller Burdock. *Arctium minus* Beruh. Possibly only a variety of *A. Lappa* L., but the prevailing plant in central Michigan. I see no way of distinguishing the achenes of one from the other; but it makes little difference as one burdock is as bad as another.

Flowers purple; achenes dull brown, often spotted with black, straight or curved, slightly flattened, oblong-prismatic with 3-5 narrowly ridged angles, and occasionally other smaller ridges, 4.5-6 mm. long. Introduced from Europe.

Biennial Wormwood. *Artemisia biennis* Willd. Achenes dark brown, smooth, somewhat flattened, 3-4 angled, obovate, narrowed at the base .8-1.3 mm. long. Native in the northwestern United States and introduced east with grass seeds. Moist land.

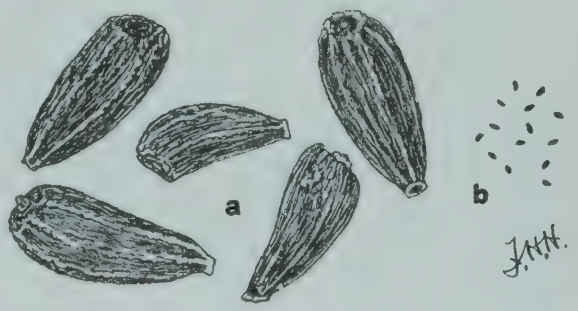


Fig. 184.

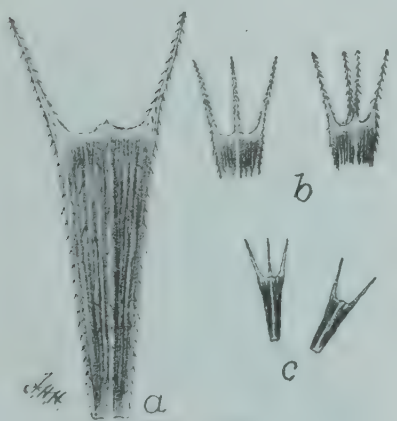


Fig. 185.

Smaller Bur-Marigold. *Bidens cernua* L. Flowers yellow; achenes 4-6 mm. long, dull brown, the awns lighter, flattened, 4-angled, wedge-shaped, awns 2-4, barbed downward as also are the ribs. Native of this country. Low lands.

Fig. 186.

Purple-stemmed Swamp Beggar-ticks. *Bidens connata* Muhl. Flowers orange; achenes brown, wedge-shaped or obovate, hairy, tubercled, flattened, 4-angled, 4-toothed, 4-6 mm. long, achenes and teeth downwardly barbed. Swamps, common.

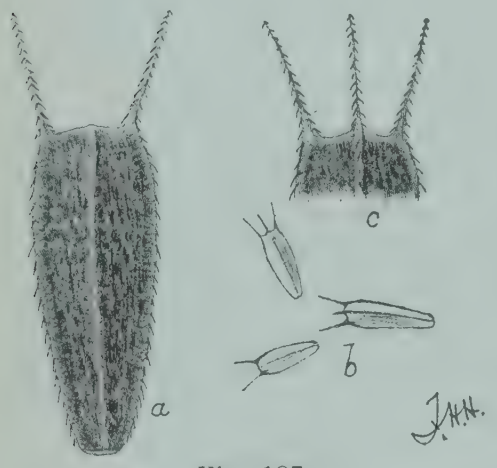


Fig. 187.

Beggar-ticks. *Bidens frondosa* L. Achenes dull brown, tubercled, much flattened, obovate or oval, 6-12 mm. long, awns usually 2, spreading barbed downward. Low lands.

Star Thistle. *Centaurea solstitialis* L. Achene cream white to mottled brown, flattened, oval about 2 mm. long; scar of attachment in a notch of one edge above the rounded base, apex truncate with a small tubercle in the middle. Found in seeds of alfalfa. A ragged plant from Europe.

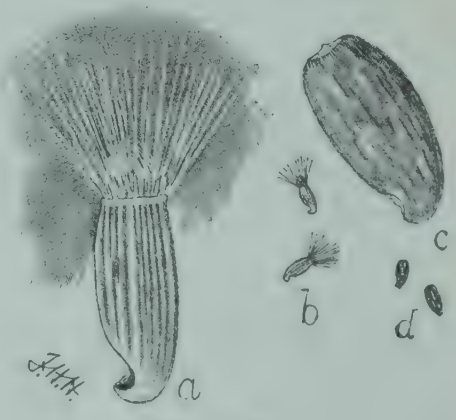


Fig. 188.

Ox-eye Daisy. *Chrysanthemum Leucanthemum* L. Flowers white; achenes brown or black with ten white conspicuous vertical ribs, nar-

Fig. 189.

rowly obovate 1.5-1.8 mm. long, bearing a tubercle at the apex. Intro-

Chickory. *Chichorium Intybus* L. Flowers yellow; achenes light brown, more or less mottled or spotted with black, straight or curved, 4-5 angled, flattened, apex truncate crowned with a double row of minute scales. Achenes 2.5-3 mm. long. Introduced from Europe.

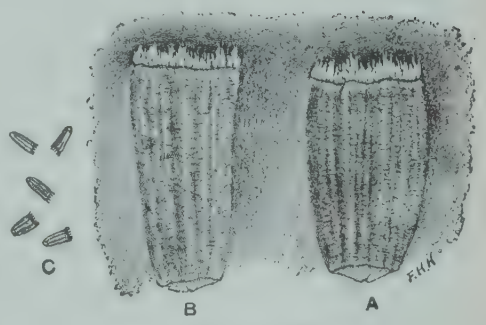


Fig. 190.

Canada Thistle. *Cirsium arvense* (L.) Scop. *Carduus arvensis* (L.) Robs. Flowers purple or white; achenes smooth, light brown, curved

Fig. 191.

or straight, narrowly obovoid or oblong, slightly flattened, 2-3 mm. long, apex truncate, cup-shaped with a tubercle in the center. Introduced from Europe. A weed of first rank.

Fig. 192.

Bull Thistle. *Cirsium lanceolatum* (L.) Hill. *Carduus lanceolatus* L. Flowers purple; achenes smooth, nearly white, with sharp vertical brown stripes, slightly flattened, obovate or oblong, usually curved near the apex, 3-4 mm. long, apex truncate with a large tubercle in the center. Introduced from Europe.

Fig. 193.

Narrow leaved Hawksbeard. *Crepis tectorum* L. Flowers yellow; achene chestnut brown, straight or curved, linear, ribs 10, smooth or rugose; 3.4 mm. long. Introduced from Europe.

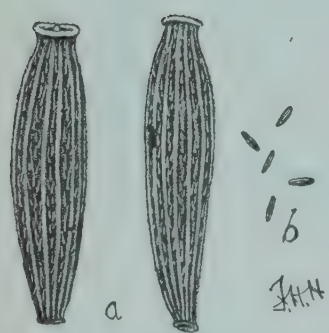


Fig. 194.

Fire-weed. *Erechtites hieracifolia* (L.) Raf. Achenes brown, linear, 2.2-2.8 mm. long, flattened, straight or curved, having ten vertical ribs between which are minute white oppressed hairs, the extremeties truncate, wider than the narrow portion beneath, the apex white with a tubercle projecting from the center of a minute cup. Native to this country. Not of much importance.

Annual Fleabane. *Erigeron annuus* (L.) Pers. Flowers white; achenes smooth, shining, brownish white, translucent, flattened, obovate or oblong. .7-.9 mm. long, bearing at the apex a whorl of very small diverging bristles, the longest ones having been rubbed off. Faint traces of a few oppressed hairs may be seen under a good lens. Native to this country and a very prominent weed in thin meadows.

Horse-weed. *Erigeron Canadensis* L. *Leptiton Canadense* (L.) Britton. Achenes oblong, dull cream color, much flattened, 1-1.3 mm. long, shining, smooth or containing a few minute oppressed bristles, apex truncate, bearing a whorl of bristles, the longest having been rubbed off. Native of this country. Compare the above description with that of Erigeron annuus. Common in waste places.

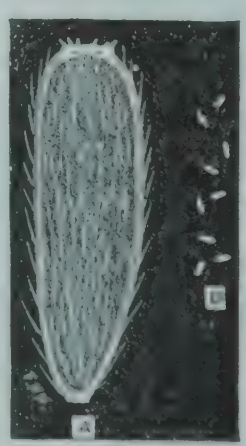


Fig. 195.

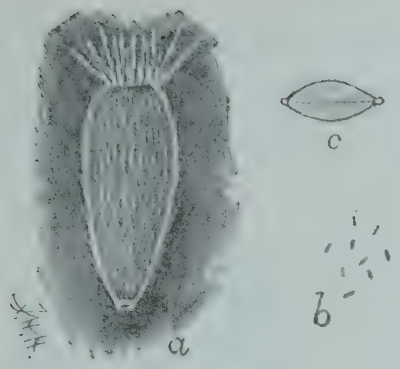


Fig. 196.

Daisy Fleabane. *Erigeron ramosus* (Walt.) B. S. P. Flowers white; achenes nearly identical with those last described, Erigeron annuus, bristles shorter, less diverging, surface bearing more minute oppressed hairs when seen under a lens. Native to this country and prominent in some thin meadows.

Sweet Everlasting. *Gnaphalium polycephalum* Michx. *Gnaphalium obtusifolium* L. Outer scales of the head thin, white, stiff; achenes yellowish white or brown, slightly flattened, smooth, oval or oblong, .5-.7 mm. long. Native to this country. Not often troublesome.

Much practice with a good lens and careful comparisons with other small achenes will be necessary in identifying such specimens as are furnished by this species.

Fig. 197.

Fig. 198.

Low Cudweed. *Gnaphalium uliginosum* L. Outer scales of the head thin, brown, more or less wooly; achenes .4-.6 mm. long, yellowish white to brown, slightly flattened, smooth, narrowly oblong .4-.6 mm. long. Achenes narrower and rather shorter than those of G. obtusifolium. Native to this country. Not of high rank as a weed.

Broad-leaved Gum Plant. *Grindelia squarrosa* (Pursh.) Dunal. Flowers yellow; achenes creamy white or light brown, very variable in appearance, more or less flattened, often 4-angled, straight to much curved, narrowed at the base, apex truncate, often concave with a distinct marginal rim, some of them not very unlike those of Canada thistle, some of them smooth, others finely grooved or ridged lengthwise, others somewhat wrinkled, 2.5-3 mm. long. Occasionally introduced from the west with seeds of grasses or clover. Usually not persistent in Michigan.

Fig. 199.

Artichoke. *Helianthus tuberosus* L. Flowers yellow; achenes black, shiny more or less, slightly flattened, pubescent with very short hairs, with four obtuse angles, narrowly obovate, 6-7 mm. long, one side of the smaller end projecting beyond the other side. Native of this country; cultivated by Indians.

Golden Mouse or Orange-Ear Hawkweed. Devil's Paint-Brush. *Hieracium aurantiacum.* Flowers orange yellow; achenes jet black, oblong, straight or curved, apex truncate, base abruptly tapering, cylindrical, the sides bearing 10 narrow, vertical ridges. Introduced from Europe. In Eastern New York and Western Massachusetts meadows abound in large areas of this vile weed, 1.8-2.2 mm. long.

Fig. 200.

Fig. 201.

Mouse-Ear Hawkweed. *Hieracium Pilosella* L. Flowers yellow; achenes jet black, oblong, straight or curved, apex truncate, base abruptly pointed, cylindrical or narrowly oval, the sides bearing 10 narrow vertical ridges. Introduced from Europe. The achenes very closely resemble those of the orange hawkweed. It doesn't matter much, for the habits are the same, and one is about as noxious as the other. Introduced from Europe.

Elecampane. *Inula Helenium* L. Flowers yellow; achenes light brown, stright or curved, linear, flattened, 4-5 mm. long, 4 sided with 5-8 obscure vertical ridges on each side, apex concave, the margin bearing a circle of short stiff bristles, the remains of longer ones. Introduced from Europe. Not common.

Fig. 202.

Fig. 203.

Marsh Elder. *Iva xanthiifolia* (Fresen.) Nutt. Achenes various shades of brown to black, flattened or rhombicin section, obovoid, 1.5-2 mm. long, longitudinally, striate with fine lines. Native to the upper peninsula of Michigan where it most likely was at one time introduced from the west. It has not been found in the lower peninsula, probably because it had no means of coming across Lake Michigan.

Fig. 204.

Wild Lettuce. *Lactuca Canadensis* L. Flowers yellow; achenes black or nearly so, flattened, oval, bearing 3 ribs, the lateral ones sometimes double, the middle one slender, surface abounding in minute transverse ridges as seen under a lens, the remains of a beak sometimes remaining. Native of this country. Other species of Lettuce are more or less troublesome.

Prickly Lettuce. *Lactuca virosa* L. For many years erroneously called *Lactuca scariola.* Flowers yellow; achenes dull, dark brown, mottled with black, flattened, bearing 5-7 rough, vertical ridges, interspersed by as many smaller ones; oblong, obovate, widest toward the tapering apex. 3-3.5 mm. long. Some of the leaves turn one edge up and the other down. Introduced from Europe and has proved itself a remarkable traveller.

Fig. 205.

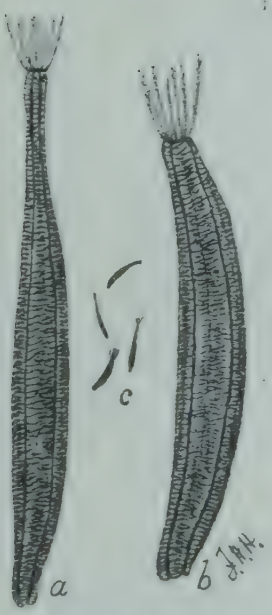


Fig. 206.

Fall Dandelion. *Leontodon autunalis* L. Flowers yellow; achenes light brown, linear, with 5 broad, rounded ribs; achene 4-6.5 mm. long, straight or curved, the outer traversed, with low transverse ridges. Introduced from Europe.

Black-eyed Susan. Yellow Daisy. *Rudbeckia hirta* L. Achene purple-brown to black, slightly tapering from base to apex 1.5-1.8 mm. long, base abruptly pointed, apex truncate, in cross section nearly square, having 5-7 slender vertical ridges on each side besides a larger one at each of the four corners. Widely distributed in meadows and pastures.

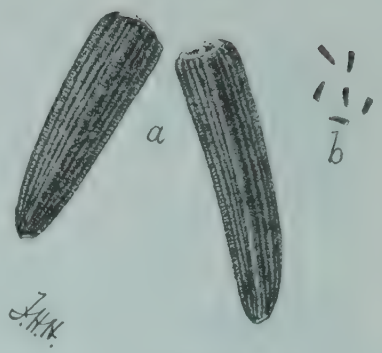


Fig. 207.

Fig. 208.

Corn Sow-Thistles. *Sonchus arvensis* L. Flowers yellow; achenes dull, dark reddish brown, oblong, extremities blunt, slightly flattened, bearing four coarse, fold-like ridges, with two smaller ridges between each of the two large ones, transversely wrinkled, 2.5-3 mm. long. This species is a perennial spreading by root-stalks as well as by seeds. Introduced from Europe.

Spiny Sow-Thistle. *Sonchus asper* (L.) Hill. Flowers pale yellow; achenes dull straw-color to reddish brown, much flattened, obovate, oblong, extremities blunt, each side bearing 3-5 vertical ridges, surface nearly smooth, 2.5-3 mm. long. Introduced from Europe.

Fig. 209.

Fig. 210.

Common Sow-Thistle. *Sonchus oleraceus* L. Flowers pale yellow; achenes reddish brown, linear, oblanceolate, 3 mm. long, flattened extremities blunt, 5 uneven wrinkled ridges on each side. Introduced from Europe.

Fig. 211.

Red-Seeded Dandelion. *Taraxacum erythrospermum* Andrz. Achene bright red or red reddish brown, flattened, oblanceolate, 3 mm. long, 1 mm. wide or less, the red beak 1 mm. long, prickles often extending nearly to the base along twelve vertical ribs, the achenes narrower, shorter, much darker in color, with prickles extending farther down the ribs, the short beak longer; the plant is earlier, often smaller, when compared with the other species.

Doubtless this is more common than has been reported, having been overlooked. Introduced from Europe.

Dandelion. *Taraxacum officinale* Weber. *Taraxacum Taraxicum* (L.) Karst. Flowers yellow; achenes dull light to dark brown, flattened oblanceolate, thread-like beak two to three times as long as the achene, the stout colored beak 0.5 mm. long. The most conspicuous character of the achenes lies in the barb-like-toothed edges and ridges of each of the similar faces, exending along the upper half. Achene, 3-4 mm. long, having twelve longitudinal ridges, 1.2 mm. wide. Introduced from Europe. Troublesome on thin lawns.

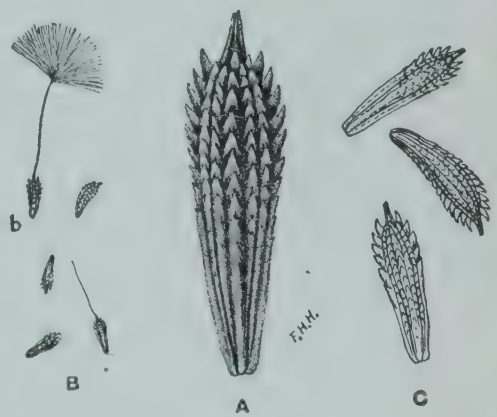


Fig. 212.

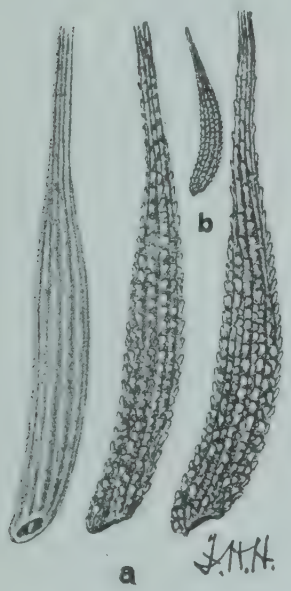


Fig. 213.

Salsify. Oyster-Plant. *Tragopogon porrifolius* L. Flowers purple; achenes dull light brown, nearly cylindrical; apex tapering, mostly terminating in a slender beak which is often longer than the body of the achene. Achene straight or curved, 10-ribbed, 12-18 mm. long, outermost coarsely roughened by upwardly directed, whitish, scale-like projections. Native of Europe.

Meadow Salsify. Yellow Goat's Beard. *Tragopogon pratensis* L. Flowers Yellow; achenes dull, light brown, nearly cylindrical, apex tapering, mostly terminating in a slender beak. Achene straight or curved, 10-ribbed, 12-15 mm. long, the inner ones of the head smooth, the outermost coarsely roughened by upwardly directed, whitish, scale-like projections. Introduced from Europe.

American Cocklebur. *Xanthium Canadensis* Mill. Achenes or burs reddish brown, oblong, circular in section, two-beaked, about 20 mm. long, covered with stout hooked prickles. Each bur encloses two seeds. Native of this country.

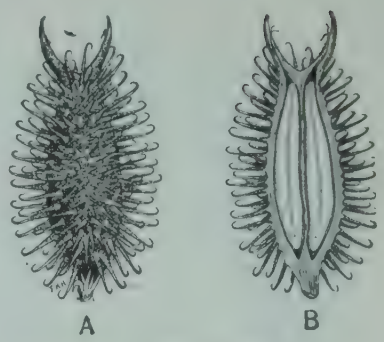


Fig. 214.

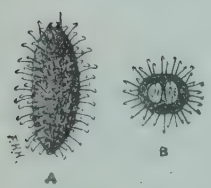


Fig. 215.

Spiny Clotbur. *Xanthium spinosum* L. Bur oblong, light brown, very slightly flattened, 10-13 mm. long, the beaks weak and small, small hooked prickles 3-4 mm. long, each bur contains two seeds. Introduced from Europe.

Broad Cocklebur. *Xanthium strumarium* L. Bur dark brown, oval, circular in sections 12-22 mm. long, beaks stout, nearly straight, spines about 5 mm. long, surface of burs and base of spines clothed with minute hooked prickles. Naturalized from Europe.

FOREWORD.

Bulletin No. 261.

The object of this report is to furnish comparative data relative to two methods of baby beef production. In one case the calves were reared on skim-milk and supplementary feed, while their mothers were milked and the product marketed. On the other hand the calves suckled their dams throughout the entire period of lactation, no other revenue being procured from them. Owing to the conditions of restraint surrounding experimental work it is difficult to realize minimum results from a standpoint of lowest actual cost of production. The feed prices established, of necessity, for the series, several years ago are somewhat low for present markets; interest on the investment has not been considered; nor has depreciation in the values of the cows. The items of labor and value of manure have not been included. These facts are left for the reader to consider in connection with his individual conditions and withdraw his own conclusions. Mention should be made of the fact that butter prices credited to the cows milked are far below the markets of the past few years.

Experiments are now in progress by which baby beeves handled similarly to the pail fed lots are being pastured during the summer season.

R. S. SHAW,
Director.

BABY BEEF FEEDING EXPERIMENTS.

The question of profitable beef production in Michigan is one of much importance involving considerable difference of opinion under present conditions. Under suitable conditions it is still profitable to produce beef by the old method of allowing the calves to run with their dams, as in some of the northern sections of the state where large areas of cheap grazing lands are found. In other sections where intensive farming is practiced, on high priced land, the returns are not sufficient to allow a profit. This statement, of course, would not apply to the raising of pure-bred animals where prices above beef values are secured. With a view toward securing data relative to this subject the Animal Husbandry Department of the Michigan Agricultural College undertook to carry on some feeding trials, starting in the fall of 1905 and continuing until the summer of 1909. The particular object of this experiment was to determine the relative profits from two ways of handling the ordinary grade beef herd:

Following one method the calves were nursed by their dams, also receiving supplementary feed, and after weaning were finished and marketed as baby beeves at eighteen months of age.

By the other method the calves were weaned at birth and reared on skim-milk with supplementary feed and finished and marketed with the other lot, while their dams were milked.

For the purpose of these experiments a herd of twenty grade cows was purchased, consisting of common or average grades, generally indicating an infusion of Shorthorn blood, such as are found on many Michigan farms where grade cattle are kept. The cows were in good condition when bought and ranged in weight from 800 to 1,150 lbs. They were bought in the fall of 1905 and were in calf to Shorthorn bulls, so the first lot of calves may be considered as Shorthorn grades. The second year the cows were bred to the pure bred Hereford bull Kington 2nd, No. 134454 and the third lot of calves were sired by the Aberdeen Angus bull, Woodcote Valiant Knight 3rd, No. 80523.

METHODS OF HANDLING THE HERDS.

HERD I.

Herd I consisted of ten cows, as already described, numbered from 1 to 10 and were allowed to suckle their calves. Each calf was permitted to run with its dam for three or four days, after which the cow was returned to the stanchion and the calf allowed to suckle twice daily, night and morning. The calves were kept in pens, three or four together, and were fed grain and roughage as soon as they could be induced to eat. Aside from picking at their bedding and at hay in their mangers, these calves would not eat much until about four months of age, and from then on the supplementary feed was gradually increased. The calves were weaned at from eight to nine months, as the cows were practically dry by that time. The cows were pastured during the summer season but the calves were kept in the barn or yards at all times, as no pasture was available for them. This unquestionably increased the cost of production very materially. Records were kept of all feed consumed by each cow during the year and the same is also true of each individual calf up to the time of marketing at approximately eighteen months of age in baby beef form.

HERD II.

Herd II consisted of ten cows numbered 11 to 20 and as nearly like numbers 1 to 10 as could be selected. These cows were milked and the calves reared on skim-milk and supplementary feed as described in Bulletin 257 of this Station, entitled "Rearing Calves on Skim-Milk and Supplementary Feed." The calves were left with their dams for a short time only, from one to three days, when they were removed and fed whole-milk from the pail for four or five weeks and then gradually changed to skim-milk, one week being required to make the change complete. In the meantime, the calves had been taught to eat grain and roughage at from two to three weeks of age, and by the time that skim-milk had entirely replaced whole milk they were well established on a ration of grain, clover or alfalfa hay and silage or roots. The skim-milk was gradually increased to about twenty pounds per head, the daily maximum feed, and was continued to eight months of age; the supplementary feed was gradually increased as the calves would take more. At eight months of age the skim-milk feeding was discontinued entirely. Through the feeding period these lots, like the calves suckled by their dams, were liberally fed to attain a finished condition at eighteen months; records were kept of all feed consumed by individual calves. The cows were milked and accurate records kept of all feed consumed and milk and butter produced.

The feeding of the two herds was alike as to kinds of feed used, the quantity being varied to meet the requirements of each animal according to the judgment of the feeder. As would be expected, Herd II con-

sumed somewhat larger amounts, per head, during the year than Herd I, the aim with each lot being to supply sufficient feed to keep the cows in good condition at all times and at as nearly constant weights as practicable. The cows in both herds were fed silage from the fall of each year until the pasture season opened the following summer. During the late summer months if the silos were empty, beet pulp, soaked in water, was fed to provide a succulent factor and one year green corn and other soiling crops were fed. In addition to the silage, some roots were fed during the winter when available. Moderate, but not heavy, grain feeding was followed through the winter and a light grain feed was given while the cows were on pasture in the summer. Clover and mixed hay and shredded corn stalks made up the balance of the ration. The grain ration was changed from time to time, of necessity, as the supply and price of feeds on the market changed. A complete list of all grain mixtures fed throughout the three years of the experiment follows:

CONCENTRATED FEED MIXTURES.

In stating the composition of grain mixtures, all parts are given by weight.

GRAIN MIXTURE NO. 1.

Corn Meal	3	parts.
Ground Oats	3	"
Wheat Bran	1	"
Oil Cake	1	"

The above was fed to all the lots of baby beeves up to one year of age. This mixture was used almost entirely with all the pail-fed calves reported in Bulletin 257 and gave very satisfactory results.

GRAIN MIXTURE NO. 2.

Corn Meal	4	parts.
Wheat Bran	2	"
Oil Cake	1	"

The preceding mixture was fed to both the suckled and skim-milk lots of the first feeding trial from one year of age until marketing time.

GRAIN MIXTURE NO. 3.

Beet Pulp	3	parts.
Corn and Cob Meal	2	"
Oil Cake	1	"

In the second feeding trial Grain Mixture No. 3 was used to replace No. 1 when the calves were twelve months old and was fed for two months, followed by No. 4.

GRAIN MIXTURE NO. 4.

Corn and Cob Meal	5 parts.
Oil Cake	2 "

This mixture was fed for about a month and a half and then replaced by No. 5, which was fed during the rest of the feeding period.

GRAIN MIXTURE NO. 5.

Corn Meal	5 parts.
Oil Cake	2 "
Cotton Seed Meal	1 "

GRAIN MIXTURE NO. 6.

Beet Pulp	4 parts.
Oil Cake	2 "
Corn Meal	1 "

In the third feeding trial Grain Mixture No. 1 was replaced at the time the baby beeves were twelve months of age by No. 6, which was fed for two months.

GRAIN MIXTURE NO. 7.

Corn Flakes	4 parts.
Oil Cake	2 "
Cotton Seed Meal	1 "
Wheat Bran	1 "

This was fed until about April 1st and followed by Grain Mixture No. 8, which was fed until the cattle of the third year were sold in June. The Corn Flakes contained in the last two grain mixtures are a by-product of one of the food factories in Battle Creek, Michigan.

GRAIN MIXTURE NO. 8.

Corn Flakes	4 parts.
Cotton Seed Meal	2 "
Oil Cake	1 "

The following grain mixtures were fed the two herds of cows, the same being used with both herds in every case.

GRAIN MIXTURE A.

Corn Meal	4 parts.
Wheat Bran	2 "
Oil Cake	1 "

The above was fed during the first year from the time the herds were brought to the College in the fall until about February 1st.

GRAIN MIXTURE B.

Corn Meal	2 parts.
Wheat Bran	2 "
Oil Cake	1 "

This mixture followed A during the remainder of the year and continued into the second feeding trial until March 1st, when the herds were changed to Grain Mixture C, which was fed during the second year.

GRAIN MIXTURE C.

Wheat Bran	4 parts.
Corn Meal	3 "
Beet Pulp	2 "
Oil Cake	1 "

GRAIN MIXTURE D.

Beet Pulp	2 parts.
Corn Meal	1 "
Wheat Bran	1 "

This was fed for a short time in the fall and followed by Grain Mixture E, which was continued through the year and made up more than ninety per cent of the total grain consumed in the third feeding trial.

GRAIN MIXTURE E.

Beet Pulp	3 parts.
Corn and Cob Meal	2 "
Oil Cake	1 "
Cotton Seed Meal	1 "

SCALE OF PRICES.

Corn Meal	$20.00 per ton.
Ground Oats	20.00 " "
Wheat Bran	18.00 " "
Linseed Meal	28.00 " "
Cotton Seed Meal	26.00 " "
Beet Pulp	15.00 " "
Corn Flakes	20.00 " "
Silage	2.50 " "
Clover Hay	5.00 " "
Roots	2.00 " "
Green Feed	2.00 " "
Pasture	5.00 per season.
Skim-milk	.20 per cwt.
Whole Milk	1.00 " "
Butter	.20 per pound.

LOT SUCKLED BY COWS—FIRST YEAR.

BABY BEEVES NOS. 1-10.

These calves were dropped in the fall of 1905, most of them during October and November. They were sired by Shorthorn bulls and out of grade beef cows 1-10, and were allowed to nurse their dams until about eight months of age, when the cows were practically dry. In addition, they were given supplementary feed of hay, silage, roots and grain, as soon as they could be induced to eat, which was about four months of age. Grain mixture No. 1 was used up to one year of age and No. 2

ILLUSTRATION 1.

during the rest of the feeding period. In figuring the actual cost of raising these calves it is necessary to add the cost of feed of the cows for one year to the cost of supplementary feed for the calves, as no other revenue was received from the cows during the year. The calves were marketed in May, 1907, at about eighteen months of age, on the local market, bringing $5.00 per cwt. They were in prime condition and would have sold much better if shipped to a good market. Illustration No. 1 shows these cattle at marketing time.

FEED CONSUMED BY BABY BEEVES, NOS. 1-10, FROM BIRTH TO 18 MONTHS OF AGE IN ADDITION TO BEING SUCKLED BY THEIR DAMS. FIRST FEEDING TRIAL.

Number.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Beet pulp, lbs.	Feed mixture, lbs.	Cost.	Weight, lbs.	Age in days.
1	2,967	1,464	180	330	2,256	$33 33	920	561
2	3,189	1,525	180	196	2,357	33 80	1,040	562
3	3,194	1,525	176	180	2,358	33 79	934	566
4	3,194	1,523	180	180	2,359	33 77	970	569
5	2,877	1,450	185	330	2,376	34 42	950	570
6	3,032	1,481	185	330	2,434	35 29	1,085	539
7	2,650	1,527	178	180	2,273	32 14	912	505
8	2,321	1,341	171	179	1,989	28 32	820	530
9	2,890	1,325	169	329	2,249	32 79	950	520
10	2,548	1,300	145	179	1,952	28 09	788	507
Averages	2,886	1,446	175	241	2,260	$32 57	937	543

The average amounts of feed consumed per head were as follows: silage 2,886 lbs., hay 1,446 lbs., roots 175 lbs., beet pulp 241 lbs., grain 2,260 lbs., making the average cost of supplementary feed $32.57 per head at 543 days, or practically eighteen months of age. The average weight at this time was 937 lbs. The cost of feed for the cows for one year must be added to this to give actual cost of production.

COWS SUCKLING CALVES, NOS. 1-10—FIRST YEAR.

These cows received silage, hay and grain during the winter and were fed a lighter grain ration while on pasture in summer. As the pasture became dry and poor in August and September, beet pulp soaked in water was fed in addition. Two grain mixtures were fed during the year, grain A during the first part and grain B during the latter part. A uniform charge of $5.00 per season was made for pasture throughout the feeding trials of this experiment.

The following table gives the feed consumed by each of the cows, 1—10 in Herd I, during the first year and cost of same.

FEED CONSUMED BY COWS, SUCKLING CALVES NOS. 1-10. FIRST YEAR.

Number.	Silage, lbs.	Hay, lbs.	Beet pulp, lbs.	Grain mixture. lbs.	Pasture.	Cost.
1	4,025	1,671	414	$5 00	1,604	$33 89
2	4,078	1,669	414	5 00	1,685	34 79
3	3,942	1,669	414	5 00	1,606	33 80
4	3,942	1,668	414	5 00	1,697	34 75
5	4,078	1,671	414	5 00	1,776	35 12
6	3,937	1,629	414	5 00	1,606	33 70
7	3,701	1,548	414	5 00	1,552	32 65
8	3,954	1,364	414	5 00	1,440	31 37
9	3,801	1,487	414	5 00	1,607	33 20
10	3,827	1,418	414	5 00	1,451	31 44
Averages	3,929	1,579	414	$5 00	1,602	$33 47

The average amount of feed consumed per head during the first year of the experiment was as follows, viz., silage 3,929 lbs., hay 1,579 lbs., beet pulp 414 lbs., grain 1,602 lbs. and pasture, making the average cost of feed for the year $33.47 per head.

Average cost of feed 1 year per cow while suckling calves	$33 47
Cost of feed consumed per calf to 18 months of age in addition to being suckled by dam	32 57
Cost of baby beeves per head at 18 months	$66 04
Average weight at 18 months	937 lbs.
Cost per cwt. to produce baby beef when calves were suckled by dams	$7 04
Price received per cwt. as sold on local market	5 00

LOT FED SKIM-MILK—FIRST YEAR.

BABY BEEVES NOS. 11-20.

These calves were the first lot in the experiment raised on skim-milk and number from 11-20. They were sired by Shorthorn bulls and out

ILLUSTRATION 2.

of grade cows 11-20 and were dropped in the fall of 1905 and fed in comparison with Nos. 1-10 reported in the preceding pages. These calves were separated from their dams at from one to three days of age and fed from the pail. Whole-milk was fed four or five weeks, then gradually replaced by skim-milk, one week being taken to make the substitution. They were taught to eat hay, grain and silage at from two to four weeks of age and were well started on the supplementary feed by the time the change to skim-milk was completed. Skim-milk was dropped from the ration at approximately eight months in each case. Grain mixture No. 1 was fed up to one year, followed by No. 2 during the rest of the feeding period. As with Nos. 1-10, the suckled lot, some green feed and moistened beet pulp were fed during the late

summer months and roots during a part of the winter. The feeding throughout the whole time was liberal with a view to finishing them for market with the other lot. Records were kept of all feed consumed by each animal from birth to marketing time.

FEED CONSUMED BY BABY BEEVES, FED SKIM-MILK, NOS. 11-20, FROM BIRTH TO 17 MONTHS OFAGE. FIRST FEEDING TRIAL.

Number.	Whole milk, lbs.	Skim-milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Beet pulp, lbs.	Green feed, lbs.	Grain mixture, lbs.	Cost.	Weight, lbs.	Age in days.
11	577	2,964	3,553	1,835	226	211	266	2,268	$46 22	868	542
12	327	3,130	3,341	1,786	226	293	188	2,305	44 59	995	511
13	456	2,890	3,367	1,731	221	141	272	2,086	41 97	910	463
14	294	3,065	3,312	1,762	226	227	185	2,206	42 51	1,010	481
15	384	2,876	2,262	1,427	226	141	272	1,703	35 14	695	497
16	450	2,964	3,411	1,838	226	306	162	2,338	46 12	915	553
17	345	3,191	3,524	1,793	226	194	272	2,224	43 63	1,051	512
18	483	2,963	3,557	1,832	226	211	272	2,267	45 26	875	544
19	339	3,114	3,484	1,705	215	141	272	2,091	41 36	956	474
20	504	2,958	3,411	1,831	226	306	188	2,341	46 68	908	548
Averages	416	3,012	3,322	1,754	224	217	235	2,183	$43 35	918	513

The average amounts of feed consumed per head from birth to marketing time were, whole milk 416 lbs., skim-milk 3,012 lbs., silage 3,322 lbs., hay 1,754 lbs., roots 224 lbs., beet pulp 217 lbs., green feed 235 lbs. and grain 2,183 lbs., making the average cost per head $43.35. The average weight at this time was 918 lbs., which compares favorably with the weight of the suckled lot, when age is considered, as the lot fed skim-milk averaged a month younger at the time of marketing and weighed only nineteen pounds less. They were in as good condition of flesh as the suckled lot and brought the same price, $5.00 per cwt., when sold with them on the local market. The cost of production for Nos. 11-20 was $4.72 per cwt. against $7.04 for the suckled lot, a difference of $2.32 per cwt. in favor of the skim-milk fed lot. In addition to the marked difference in the actual cost of production of baby beef from the two herds, the cows of Herd II were milked and some interesting figures may be shown in regard to milk and butter produced as follows:

COWS MILKED, NOS. 11-20—FIRST YEAR.

These cows Nos. 11-20 were handled exactly similar to cows 1-10 as to quantity and kinds of feed consumed, variation being made in the quantity fed according to the judgment of the feeder.

FEED CONSUMED BY COWS MILKED, NOS. 11-20. FIRST YEAR.

Number.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Beet pulp, lbs.	Green feed, lbs.	Pasture.	Grain mixture, lbs.	Cost.
11	4,076	1,738	1,130	700	440	$5 00	1,774	$39 60
12	3,628	1,315	1,130	557	440	5 00	1,564	34 75
13	2,757	916	1,130	550	440	5 00	1,182	28 70
14	3,750	1,209	990	646	440	5 00	1,486	34 40
15	3,993	1,321	560	646	440	5 00	1,425	33 90
16	3,823	1,588	1,130	646	440	5 00	1,610	36 80
17	3,383	1,226	560	550	440	5 00	1,704	35 07
18	3,834	1,604	560	550	440	5 00	1,637	35 86
19	2,745	950	560	638	440	5 00	1,274	29 81
20	4,006	1,596	560	550	440	5 00	1,790	37 63
Averages	3,600	1,346	831	603	440	$5 00	1,545	$34 65

The average feed consumed per head during the year was, silage 3,600 lbs., hay 1,346 lbs., roots 831 lbs., beet pulp 603 lbs., green feed 440 lbs., grain 1,545 lbs. and pasture. The cost of feed was $34.65 per head.

MILK AND BUTTER PRODUCED BY COWS, NOS. 11-20. FIRST YEAR.

Number.	Milk, lbs.	Butter, lbs.	Skim-milk, lbs.	Value of products.	Cost of feed.	Profit over cost of feed.
11	5,365	247.4	4,292	$59 06	$39 60	$19 46
12	5,684	255.0	4,548	60 09	34 75	25 34
13	4,002	174.2	3,202	41 24	28 70	12 54
14	5,549	268.7	4,439	62 61	34 40	28 21
15	4,886	232.5	3,909	54 32	33 90	20 42
16	5,722	290.0	4,578	66 35	36 80	29 55
17	5,832	271.8	4,665	63 69	35 07	28 62
18	6,256	278.7	5,005	65 76	35 86	29 90
19	4,267	187.0	3,413	44 22	29 81	14 41
20	5,737	276.8	4,589	64 53	37 63	26 91
Averages	5,330	248.2	4,264	$58 19	$34 65	$23 54

In determining the amounts of butter produced daily records were kept of all milk produced by each cow and composite samples were tested weekly for butter fat. Butter is figured by the 85.7 per cent rule, adding one-sixth to butter fat to give the weight of butter. Skim-milk is figured as 80 per cent of the total production of whole milk and is rated at twenty cents per cwt., while butter is valued at twenty cents per pound. During the first year the ten cows produced an average of 5,330 lbs. milk containing 248.2 lbs. butter with a total value of products of $58.19 per head. The food cost of production was $34.65, leaving a profit of $23.54 per head above the cost of feed.

SUMMARY OF RESULTS—FIRST YEAR.

Average cost of feed, 1 year, for 10 cows suckling their calves	$33 47
Average cost of additional feed consumed by each calf up to 18 months of age	32 57
Total cost of baby beeves per head	$66 04
Average weight per head	937 lbs.
Average cost of production per cwt	$7 04

No other revenue from the ten cows.

Average cost of feed consumed by 10 baby beeves to 17 months of age, raised by skim-milk method.	$43 35
Average weight	918 lbs.
Average cost of production per cwt	$4 72
Average value of butter and skim-milk produced during the year by 10 cows, dams of skim-milk fed baby beeves	$58 19
Average cost of feed per cow during the year	34 65
Average profit per cow over cost of feed	$23 54

LOT SUCKLED BY COWS—SECOND YEAR.

BABY BEEVES NOS. 1a-10a.

Calves Nos. 1a-10a were dropped during the fall of 1906 and were allowed to suckle their dams as Nos. 1-10 of the preceding year. They were out of the same cows, grade beef herd cows 1-10, but were sired by Kington 2nd, the bull at the head of the College herd of Herefords at that time. They were handled in much the same manner as Nos. 1-10 had been and were liberally fed to finish for market at eighteen months of age and were sold in May, 1908. See illustration 3. They

ILLUSTRATION 3.

received less beet pulp than the preceding lot and no roots. Four grain mixtures were used, viz.: No. 1 to about one year of age, No. 3 for the next two months, No. 4 from January 15th to March 1st and No. 5 during the rest of the feeding period ending in May. In addition to the regular grain ration, ear corn was fed in moderate quantities during March and April.

FEED CONSUMED BY BABY BEEVES, NOS. 1a–10a, FROM BIRTH TO 18 MONTHS OF AGE, IN ADDITION TO BEING SUCKLED BY THEIR DAMS. SECOND FEEDING TRIAL.

Number.	Silage, lbs.	Hay, lbs.	Beet pulp, lbs.	Ear corn, lbs.	Grain mixture, lbs.	Cost.	Weight, lbs.	Age in days.
1a	2,532	1,492	94	107	1,605	$24 00	850	507
2a	3,159	1,708	96	227	2,363	35 65	1,008	544
3a	3,162	1,655	93	227	2,371	35 58	1,008	559
4a	3,188	1,730	110	227	2,473	35 49	994	555
5a	3,187	1,768	110	227	2,488	37 25	1,036	578
6a	3,187	1,758	113	227	2,494	37 29	1,237	563
*								
8a	3,144	1,467	99	227	2,249	33 87	960	455
9a	3,190	1,793	113	227	2,494	37 39	1,127	556
10a	3,144	1,591	99	227	2,316	34 87	927	520
Averages	3,099	1,662	103	214	2,317	$34 60	1,016	537

*Cow No. 7 died during the summer of 1906 and therefore is not included in the second feeding trial. For the third feeding trial another cow was substituted.

The average feed consumed per head was, silage 3,099 lbs., hay 1,662 lbs., beet pulp 103 lbs., ear corn 214 lbs. and grain 2,317 lbs., at an average cost of $34.60. The age at the time of selling was eighteen months and the average weight 1,016 lbs. per head.

FEED CONSUMED BY COWS, SUCKLING CALVES NOS. 1-10. SECOND YEAR.

Number.	Silage, lbs.	Hay, lbs.	Beet pulp, lbs.	Pasture.	Grain mixture, lbs.	Cost.
1	5,036	836	30	$5 00	1,718	$30 73
2	4,140	869	24	5 00	1,569	28 08
3	5,018	986	115	5 00	1,820	32 62
4	5,170	1,037	43	5 00	1,719	31 45
5	5,286	1,006	23	5 00	1,742	31 74
6	5,596	1,058	53	5 00	1,723	32 17
8	4,798	907	69	5 00	1,547	25 05
9	4,956	1,061	245	5 00	1,176	35 41
10	3,734	793	53	5 00	2,000	28 51
Averages	4,859	950	73	$5 00	1,672	$30 64

The average amount of feed consumed per head was, silage 4,859 lbs., hay 950 lbs., beet pulp 73 lbs., grain 1,672 lbs. and pasture, at a cost of $30.64 per head. This amount added to the cost of feed for the calf gives the actual cost of production of the baby beeves when eighteen months of age.

Average cost per head of feed for Cows 1-10, second year, while suckling calves	$30 64
Average cost of feed consumed by baby beeves in addition to sucking cows	34 60
Actual cost per head at 18 months	$65 24
Average weight per head at 18 months	1,016 lbs.
Cost per cwt. to produce baby beef by suckling methods	$6 44

LOT FED SKIM-MILK—SECOND YEAR.

BABY BEEVES NOS. 11a-20a.

These calves were the second lot raised by the skim-milk method and were dropped in the fall of 1906 and marketed at eighteen months of age with Nos. 1a-10a in May, 1908. See illustration 4. They were from the

ILLUSTRATION 4.

same cows of the grade beef herd, Nos. 11-20, as the preceding lot of pail-fed calves but were sired by the pure-bred Hereford bull Kington 2nd. They were handled very much the same as the preceding lot of skim-milkers but received no roots nor green feed. They were fed the same grain mixtures as Nos. 1a-10a, the lot suckled by their dams, and also received ear corn in addition to the other grain in March and April.

FEED CONSUMED BY BABY BEEVES, FED SKIM-MILK, NOS. 11a-20a FROM BIRTH TO 18 1-2 MONTHS OF AGE. SECOND FEEDING TRIAL.

Number.	Whole milk, lbs.	Skim-milk, lbs.	Silage, lbs.	Hay, lbs.	Beet pulp, lbs.	Ear corn, lbs.	Grain mixture, lbs.	Cost.	Weight, lbs.	Age in days.
11a	379	4,130	3,186	1,924	142	218	2,821	$53 27	1,018	557
12a	354	4,549	3,186	1,863	142	218	2,824	53 54	958	557
13a	371	4,531	3,174	1,857	142	218	2,797	53 59	902	554
14a	338	4,016	3,186	1,843	142	218	2,775	51 75	984	515
15a	398	4,448	3,171	1,845	142	218	2,795	53 41	995	537
16a	407	3,249	3,187	1,924	142	218	2,858	51 97	963	567
17a	586	4,712	3,186	1,923	142	218	2,820	56 28	1,069	576
18a	357	4,684	3,186	1,927	142	218	2,821	53 92	1,081	562
19a	408	4,712	3,186	1,923	142	218	2,821	54 51	986	567
20a	383	3,470	3,186	1,895	142	218	2,816	51 66	861	558
Averages	398	4,250	3,183	1,892	142	218	2,815	$53 39	982	555

The average amount of feed consumed per head by this lot from birth to eighteen and a half months of age was as follows: whole milk 398 lbs., skim-milk 4,250 lbs., silage 3,183 lbs., hay 1,892 lbs., beet pulp 142 lbs., ear corn 218 lbs. and grain 2,815 lbs., at a cost of $53.39 per head. This is a much higher cost than for the skim-milk fed lot of the preceding year; due principally to heavier grain feeding. The average weight was 982 lbs. per head, making the cost of production $5.42 per cwt.

FEED CONSUMED BY COWS MILKED, NOS. 11-20. SECOND YEAR.

Number.	Silage, lbs.	Hay, lbs.	Beet pulp, lbs.	Pasture.	Grain mixture, lbs.	Cost.
11	5,434	914	53	$5 00	1,827	$32 65
12	5,796	1,020	67	5 00	1,731	32 56
13	6,972	972	103	5 00	1,803	34 67
14	6,147	1,096	103	5 00	1,795	33 76
15	4,314	766	53	5 00	1,504	27 53
16	5,816	962	53	5 00	1,804	33 07
17	6,046	992	58	5 00	2,080	36 35
18	5,492	912	45	5 00	1,686	31 33
19	6,224	1,024	44	5 00	2,023	35 88
20	6,145	996	103	5 00	2,017	35 93
Averages	5,839	965	68	$5 00	1,827	$33 37

The cows consumed on an average, silage 5,839 lbs., hay 965 lbs., beet pulp 68 lbs., grain 1,827 lbs. and pasture, at a cost of $33.37 per head.

MILK AND BUTTER PRODUCED BY COWS, NOS. 11-20. SECOND YEAR.

Number.	Milk, lbs.	Butter, lbs.	Skim-milk, lbs.	Value of products.	Cost of feed.	Profit over cost of feed.
11	6,016	273.1	4,813	$64 25	$32 65	$31 60
12	6,217	276.4	4,974	65 23	32 56	32 67
13	5,252	233.6	4,202	55 12	34 67	20 45
14	5,569	248.8	4,455	58 67	33 76	24.91
15	4,696	213.0	3,757	50 11	27 53	22.58
16	5,591	284.2	4,473	65 79	33 07	32 72
17	5,967	272.7	4,774	64 09	36 35	27 74
18	4,446	206.1	3,557	48 33	31 33	17 00
19	6,096	260.0	4,877	61 75	35 88	25 87
20	6,867	331.6	5,494	77 31	35 93	41 38
Averages	5,672	260.0	4,538	$61 07	$33 37	$27 70

The average milk production was 5,672 lbs. containing 260 lbs. butter. This gives a total value of butter and skim-milk of $61.07 per head at a food cost of $33.37, a profit of $27.70 per head over the cost of feed.

SUMMARY OF RESULTS—SECOND FEEDING TRIAL.

Average cost of feed, 1 year, for 10 cows suckling their calves	$30 64
Average cost of additional feed consumed by each calf up to 18 months of age	34 60
Total cost of baby beeves per head	$65 24
Average weight per head	1,016 lbs.
Average cost of production per cwt.	$6 44

No other revenue from the ten cows.

Average cost of feed consumed by 10 baby beeves to 18½ months of age, raised by skim-milk method	$53 39
Average weight	982 lbs.
Average cost of production per cwt.	$5 42
Average value of butter and skim-milk produced during the year by 10 cows, dams of skim-milk fed baby beeves	$61 07
Average cost of feed per cow during the year	33 37
Average profit per cow over cost of feed	$27 70

The two lots of calves, in the second test, were sold together and no discrimination made by the buyers against the skim-milk fed lot as they were in as good condition of flesh and as well finished as the other lot and weighed nearly as much per head. The entire number brought $5.75 per cwt. when contracted to local shippers about a month previous to shipment and were weighed up at the college on the morning they were shipped. They were placed on the Detroit market and brought $6.85, and were commented on very favorably in the market columns of the Detroit papers of that date.

LOT SUCKLED BY COWS—THIRD YEAR.

BABY BEEVES NOS. 1b-10b.

Calves 1b-10b were dropped during the fall of 1907 and were handled in the same manner as Nos. 1-10 and 1a-10a of the two preceding years. They were out of grade beef cows Nos. 1-10 and sired by a pure bred Aberdeen Angus bull, Woodcote Valiant Knight 3rd, then at the head of the College herd of Angus. They were finished and marketed in the spring of 1909 at about eighteen months of age, as the other lots had been. Nos. 4b and 8b died, and only eight head are reported in this lot. They received silage, hay and grain in addition to being suckled by their dams. Grain mixture No. 1 was used up to about one year of age, followed by No. 6, No. 7 and No. 8.

FEED CONSUMED BY BABY BEEVES, NOS. 1b-10b, FROM BIRTH TO 19 MONTHS OF AGE, IN ADDITION TO BEING SUCKLED BY THEIR DAMS. THIRD FEEDING TRIAL.

Number.	Silage, lbs.	Hay, lbs.	Grain mixture, lbs.	Cost.	Weight. lbs.	Age in days.
1b	2,849	1,638	2,599	$36 83	1,033	579
2b	2,839	1,626	2,576	36 54	993	609
3b	2,663	1,510	2,293	32 94	1,004	533
5b	2,850	1,605	2,593	36 69	1,045	582
6b	2,767	1,531	2,510	35 47	1,015	560
7b	2,634	1,484	2,277	32 67	923	501
9b	2,831	1,778	2,969	40 91	1,141	567
10b	2,870	1,835	3,084	42 30	1,103	534
Averages	2,788	1,626	2,612	$36 79	1,032	558

These eight head consumed from birth to eighteen and a half months of age, silage 2,788 lbs., hay 1,626 lbs. and grain 2,612 lbs. in addition to being suckled by their dams. The cost of this feed was $36.79 per head and the average weight was 1,032 lbs.

FEED CONSUMED BY COWS, SUCKLING CALVES, NOS. 1-10. THIRD YEAR.

Number.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Beet pulp, lbs.	Pasture.	Grain mixture, lbs.	Cost.
1	5,859	1,167	653	592	$5 00	1,380	$33 59
2	6,517	1,150	758	636	5 00	1,490	35 66
3	6,297	869	653	334	5 00	1,364	30 74
5	5,856	1,180	473	623	5 00	1,483	34 60
6	5,695	928	638	633	5 00	1,330	32 69
7	7,138	1,055	653	365	5 00	1,125	30 82
9	6,818	1,269	366	106	5 00	1,530	32 55
10	6,407	1,144	653	178	5 00	1,480	32 17
Averages	6,323	1,095	606	433	$5 00	1,398	$32 85

The dams of the two calves that died are omitted.

During the year these cows consumed an average of silage 6.323 lbs., hay 1,095 lbs., roots 606 lbs., beet pulp 433 lbs., grain 1,398 lbs. and pasture, at an average cost of $32.85 per head. This added to the cost of the feed consumed by baby beeves Nos. 1b-10b gives their actual cost as follows:

Average cost per head for cows 1-10 during third year while suckling calves	$32 85
Average cost of feed consumed by baby beeves 1b-10b from birth to 19 months of age in addition to being suckled by dams	36 79
Actual cost per head	$69 64
Average weight per head	1,032 lbs.
Cost of production per cwt	$6 78

LOT FED SKIM-MILK—THIRD YEAR.

BABY BEEVES NOS. 11b-20b.

These calves were the third lot raised by the skim-milk method, were dropped in the fall of 1907 and marketed with Nos. 1b-10b in June, 1909. See illustration 5. They were from the same cows, grade beef cows 11-20, as the skim-milk fed lots of the two preceding years and were sired by the pure bred Aberdeen Angus bull, Woodcote Valiant Knight 3rd. They were handled much the same as the other two skim-milk fed lots but received no beet pulp or green feed. They were fed grain mixture Nos. 1, 6, 7 and 8, the same as Nos. 1b-10b, the suckled lot of the same year.

ILLUSTRATION 5.

FEED CONSUMED BY BABY BEEVES, FED SKIM-MILK, NOS. 11b–20b, FROM BIRTH TO 18 MONTHS OF AGE. THIRD FEEDING TRIAL.

Number.	Whole milk lbs.	Skim-milk, lbs.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Grain mixture, lbs.	Cost.	Weight, lbs.	Age in days.
11b	327	4,749	3,188	2,260	231	3,365	$59 76	1,031	586
12b	395	4,055	3,000	2,060	156	3,112	55 62	1,118	560
13b	345	3,246	2,670	1,655	62	2,499	45 45	931	454
14b	479	3,707	2,936	1,943	177	3,079	55 08	1,129	517
15b	440	4,117	2,093	2,161	159	3,204	56 29	1,093	622
16b	419	4,304	2,921	2,035	155	3,022	55 19	929	555
17b	503	4,056	2,890	1,850	99	2,984	54 63	1,039	504
18b	419	5,044	3,150	2,130	177	3,266	59 81	909	612
19b	520	4,219	2,814	1,861	89	2,725	52 31	832	510
20b	592	3,689	2,904	1,980	177	3,103	56 49	975	531
Averages....	444	4,119	2,857	1,994	148	3,036	$55 06	999	545

The average feed consumed per head by this lot from birth to eighteen months of age was as follows: whole milk 444 lbs., skim-milk 4,119 lbs., silage 2,857 lbs., hay 1,994 lbs., roots 148 lbs., grain 3,036 lbs., at an average cost of $55.06 per head. Like the last lot of skim-milk fed calves, these ten head were fed a much heavier grain ration than the first lot, and this accounts largely for the increase in cost. The average weight was 999 lbs. per head, making the cost of production $5.51 per cwt.

FEED CONSUMED BY COWS MILKED, NOS. 11-20. THIRD YEAR.

Number.	Silage, lbs.	Hay, lbs.	Roots, lbs.	Beet pulp, lbs.	Pasture.	Grain mixture, lbs.	Cost.
11	9,281	1,296	638	96	$5 00	1,494	$35 49
12	8,572	1,303	584	96	5 00	2,109	40 67
13	6,666	1,319	842	171	5 00	1,630	34 45
14	5,650	778	548	54	5 00	1,084	25 44
15	7,122	1,342	1,889	54	5 00	1,775	36 71
16	5,491	1,045	1,964	80	5 00	1,457	31 13
17	5,898	1,626	1,530	200	5 00	1,255	31 60
18	8,068	1,202	758	54	5 00	1,449	32 99
19	6,931	1,232	820	96	5 00	1,540	33 18
20	7,438	935	608	72	5 00	1,610	33 36
Averages	7,112	1,208	1,018	97	$5 00	1,540	$33 50

The average amount of feed consumed by the ten cows during the third year of the test was as follows: silage 7,112 lbs., hay 1,208 lbs., roots 1,018 lbs., beet pulp 97 lbs., grain 1,540 lbs. and pasture, making the cost of feed $33.50 per head.

MILK AND BUTTER PRODUCED BY COWS, NOS. 11-20. THIRD YEAR.

Number.	Milk, lbs.	Butter, lbs.	Skim-milk, lbs.	Value of products.	Cost of feed.	Profit over cost of feed.
11	7,433	328.1	5,946	$77 51	$35 49	$42 02
12	7,030	340.8	5,624	79 41	40 67	38 74
13	5,444	272.4	4,355	63 19	34 45	28 74
14	5,457	247.6	4,366	58 25	25 44	32 81
15	6,769	308.3	5,415	72 49	36 71	35 78
16	4,357	244.1	3,486	55 79	31 13	24 66
17	3,895	186.3	3,116	43 49	31 60	11 89
18	6,704	300.9	5,363	70 91	32 99	37 92
19	3,931	168.8	3,145	40 05	33 18	6 87
20	7,129	342.4	5,703	79 89	33 36	46 53
Averages	5,815	274.0	4,652	$64 10	$33 50	$30 60

These ten cows averaged 5,815 lbs. milk and 274 lbs. of butter valued at $64.10 and produced at a cost of $33.50 per head, leaving a profit over the cost of feed of $30.60 per head.

SUMMARY OF RESULTS—THIRD FEEDING TRIAL.

Average cost of feed, 1 year, for cows suckling their calves	$32.85
Average cost of additional feed consumed by each calf up to 19 months of age	36 79
Total cost of baby beeves per head	$69 64
Average weight per head	1,032 lbs.
Average cost of production per cwt	$6.78

No other revenue from the cows.

Average cost of feed consumed by 10 baby beeves to 18 months of age, raised by skim-milk method.	$55 06
Average weight	999 lbs.
Average cost of production per cwt	$5 51
Average value of butter and skim-milk produced during the year by 10 cows, dams of skim-milk fed baby beeves	$64 10
Average cost of feed per cow during the year	33 50
Average profit per cow over cost of feed	$30 60

Both lots of baby beeves of the third feeding trial were contracted to local shippers at $6.15 per cwt. and were weighed and sold at the College in June, 1909. They were shipped to Buffalo and slaughtered by the C. Klinck Packing Company. The quality was so nearly the same in the two lots that no discrimination was made by the buyers. They were in excellent condition and brought $7.25 on the Buffalo market. The following statement was made by the Klinck Packing Company in a letter addressed to the Animal Husbandry Department at the College, regarding the consignment: "We are pleased to state that this is positively the best load of cattle that we have killed in a long time and your institution certainly deserves a great deal of credit for the good results shown."

FINAL SUMMARY OF RESULTS.

SUMMARY OF RESULTS FOR THREE YEARS—HERD I.

Average cost of feed per year for cows suckling calves	$32 32
Average cost of feed, additional to being suckled by dams, consumed by baby beeves from birth to close of feeding period, 18 months of age	34 65
Average cost per head of baby beeves	$66 97
Average weight per head	995 lbs.
Average cost of production per cwt	$6 73

No other revenue from the cows.

SUMMARY OF RESULTS FOR THREE YEARS—HERD II.

Average cost of feed consumed by baby beeves raised by skim-milk method	$50 77
Average weight per head	966 lbs.
Average cost of production per cwt	$5 24
Average value of butter and skim-milk produced per year by cows, dams of skim-milk fed baby beeves	$61 12
Average cost of feed per head per year	33 84
Average profit per head over cost of feed	$27 28

The summary of results for three years with the two herds shows that with Herd I where the cows suckled the calves, beef was produced at a cost of $6.73 per cwt., while with Herd II where the cows were milked and the calves raised on skim-milk, the cost of beef production was $5.24 per cwt., a difference of $1.49 per cwt. in favor of the skim-milk fed lot in economy of production. No other revenue was obtained from Herd I, while the cows of Herd II were milked and returned a profit of $27.28 per head over the cost of feed. The skim-milk fed lots of baby beeves of the three years showed as good condition of flesh and quality as the suckled lots and were nearly equal in weight. The skim-milk lots averaged 966 lbs. at marketing time as compared to 995 lbs. for the suckled lots, a difference of 29 lbs. per head. The average age at the time of marketing was 532 days for the suckled lot and 537 days for the skim-milkers, which is a little under eighteen months average age with all the lots.

Lot number.	Skim-milk fed lots at six months.			Suckled lots at six months.		
	Weight, lbs.	Cost.	Cost per cwt.	Weight, lbs.	Cost.	Cost per cwt.
1	380	$13 28	$3 49	458	$19 14	$4 17
2	352	12 55	3 56	417	16 58	3 97
3	376	14 63	3 86	433	17 89	4 13
Averages	369	$13 49	$3 65	436	$17 87	$4 13

At six months of age the skim-milk fed calves of the three feeding trials averaged 369 lbs. and had consumed $13.49 worth of feed, making the cost of production $3.65 per cwt. at the same time the calves that were suckled by their dams weighed 436 lbs. and had cost $17.87, or $4.13 per cwt. The suckled calves weighed 67 lbs. more at six months of age but had cost $4.38 more per head and forty-eight cents more per cwt. than the skim-milk fed lot.

Lot number.	Skim-milk fed lots at one year.			Suckled lots at one year.		
	Weight, lbs.	Cost.	Cost per cwt.	Weight, lbs.	Cost.	Cost per cwt.
1	644	$27 69	$4 32	753	$48 49	$6 43
2	629	26 78	4 20	702	40 25	5 73
3	682	32 53	4 79	766	45 14	5 89
Averages	652	$29 00	$4 44	740	$44 63	$6 03

At one year of age the skim-milk fed calves averaged 652 lbs. and had cost $29.00 per head or $4.44 per cwt., while the suckled calves weighed 740 lbs. and had cost $44.63 per head or $6.03 per cwt. This shows a wider difference than at six months. The suckled calves were 88 lbs. heavier at one year of age than the skim-milk fed calves but had cost $15.63 per head more and the cost per cwt. at this time was $1.59 more than for the skim-milk fed calves.

Lot number.	Skim-milk fed lots at 18 months.			Suckled lots at 18 months.		
	Weight lbs.	Cost.	Cost per cwt.	Weight, lbs.	Cost.	Cost per cwt.
1	918	$43 35	$4 72	937	$66 04	$7 04
2	982	53 39	5 42	1,016	65 24	6 44
3	999	55 06	5 51	1,032	69 64	6 78
Averages	966	$50 60	$5 23	995	$66 97	$6 73

At eighteen months of age, when the baby beeves were marketed, the skim-milk calves had nearly caught up with the others in weight, the difference being only 29 lbs. per head in favor of the suckled lots, while the cost per head was $16.37 less with the skim-milkers and the average cost of production was $1.50 less per cwt.

From these figures it would seem safe to conclude that baby beef production by the skim-milk method is much cheaper and gives better results than by the suckling method. When marketed at an average age of eighteen months, calves raised on skim-milk weighed 966 lbs. while those that had suckled their dams weighed 995 lbs., which is not a wide difference in weight. The skim-milk fed baby beeves cost $50.60 per head while the suckled baby beeves cost $66.97 per head, a difference of $16.37 per head in favor of the former method. The skim-milk baby beeves were produced for $5.23 per cwt. as compared to a cost of $6.73 per cwt. for the others, a difference in economy of production of $1.50 per cwt. in favor of the skim-milk fed animals.

Further, from the cows of Herd I, where the calves nursed, no other revenue was secured, while the cows of Herd II, the dams of the skim-milk fed calves, returned a profit of $27.28 per head in butter and skim-milk values over and above the cost of feed consumed.

The quality of the baby beeves produced by the two methods was practically the same and the skim-milk lots brought the same prices as the suckled lots when put on the market. As noted before, the cost of production is undoubtedly higher than it would be under ordinary farm conditions, but nevertheless, the figures as given show the comparative costs and values correctly and conclusions as to the methods of feeding may be safely drawn.

FOREWORD.

Special Bulletin No. 51.

All fruit trees, bushes and vines are attacked by many insects and diseases that may destroy the crop entirely or very seriously lessen its value. *Fruit buyers and dealers do not care to buy or handle fruit from orchards that have not been well sprayed.*

Proper, thorough and systematic spraying will protect the tree or bush and insure a larger percentage of good, marketable fruit.

This outline aims to give methods of control for the more common insects and diseases only. For pests not included, write to the Department of Entomology or the Department of Horticulture, East Lansing, Mich., as the case may be. Or consult special bulletin 24, and regular bulletins 233 and 219.

GENERAL TREATMENT FOR APPLE ORCHARDS.

When to Spray.	*What to Use and What For.*
As late as possible before buds start.	Lime-sulphur wash, if San Jose scale is present. This scale must be destroyed or it will ruin the trees. For scurvy scale use lime-sulphur wash as late as possible before buds swell.
Just before the blossoms open.	Bordeaux mixture for scab, leaf-spot diseases and canker, with poison for canker-worm and bud-moth. The results of some growers indicate that this spraying may be omitted if one has been made with lime-sulphur for San Jose scale, unless canker-worm is present.
Just after the blossoms fall and stamens wither.	Bordeaux mixture for the diseases mentioned before with a poison for bud-moth, tussock-moth, codling-moth and other insects. This and the last are the most important single sprayings, do not neglect them.
Ten days to 2 weeks after the previous spraying.	Bordeaux mixture and arsenicals for diseases and insects mentioned above.
First week in August.	Bordeaux-mixture, not full strength, and poison, full strength, for the second brood of codling-moths. This is an important spraying, especially for late fall and winter varieties. The self-boiled lime-sulphur may be used in place of the Bordeaux mixture for varieties like Jonathan and Wagener that are liable to russet badly. The lesser apple-worm, when present, requires a spray of poison when standard winter varieties are from 1 to 1½ inches in diameter.

GENERAL TREATMENT FOR PEARS.

When to Spray.	*What to Use and What For.*
Same as for apple.	Lime-sulphur for San Jose scale, blister-mite and pear-psylla, if present. For scurfy scale use lime-sulphur as late as possible before buds open. Bordeaux mixture with poison as directed for the apple.
Pear blight.	Whenever a blighted branch is found, cut back to sound wood and burn. Systematic inspections made during fall, winter, and early spring, a short time before blossoms open, to remove all "winter hold-over" cases, is very beneficial. After each branch is cut, disinfect tool by wiping with a cloth or sponge moistened with 5 % carbolic acid. If "slugs" appear, spray with an arsenical, if not too near ripening of fruit to be dangerous. In case of early pears, dust with fresh hydrated lime.

GENERAL TREATMENT FOR PEACHES.*

When to Spray.	*What to Use and What For.*
Early in the spring, surely before the buds swell.	Lime-sulphur wash for San Jose scale, if present. This spraying will also answer for the leaf-curl. If San Jose scale is not present, Bordeaux mixture for the leaf curl.

FOR ORCHARDS AFFECTED WITH THE BROWN ROT, SCAB, AND CURCULIO.

When to Spray.	*What to Use and What For.*
1st time.	About the time the shucks are shedding, spray with arsenate of lead at rate of 2 pounds to 50 gallons of water.
2nd time.	Two to three weeks later or about one month after the petals drop, spray with 8-8-50 self-boiled lime-sulphur and 2 pounds arsenate of lead.
3rd time.	About one month before the fruit ripens repeat the above spraying, omitting the poison.

For early varieties the first two sprayings will probably be sufficient, unless the season is very wet and the varieties very susceptible to rot.

FOR BROWN ROT AND SCAB, WHERE THE CURCULIO IS NOT TROUBLESOME.

When to Spray.	*What to Use and What For.*
1st time.	Two or three weeks after the petals fall, with 8-8-50 self-boiled lime-sulphur.
2nd time.	About three weeks later, repeat previous spraying.
3rd time.	About one month before fruit is expected to ripen, repeat previous spraying.

FOR SCAB ONLY.

When to Spray.	*What to Use and What For.*
	About one month after petals fall, spray with 8-8-50 self-boiled lime-sulphur and again three or four weeks later.

In applying the self-boiled lime-sulphur mixture, special care must be taken to keep it well agitated. The mixture settles rapidly and unless well agitated it will not be evenly sprayed. With the last spraying use fine nozzles and give the trees a uniform coating of a mist-like spray.

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*This line of treatment and the preparation of the self-boiled lime- sulphur mixture are based upon the recent successful experiments of the Bureau of Plant Industry of the Department of Agriculture.

GENERAL TREATMENT FOR CHERRIES.

When to Spray.	*What to Use and What For.*
Early in the spring before growth starts.	Lime-sulphur wash, if San Jose scale is present. The same as for apple trees.
Just before the blossoms open.	Bordeaux mixture for fruit-rot and leaf-spot. This is especially valuable on English Morellos for leaf-spot.
Just after the blossoms fall.	Bordeaux mixture for fruit-rot and leaf-spot, with arsenate of lead for curculio and slug.
Ten days to 2 weeks later.	Bordeaux mixture for fruit-rot and leaf-spot. This spraying may not be necessary, depending upon the susceptibility of the variety to fruit-rot and the weather conditions of the season. The large, black lice may be killed with tobacco water, if it is applied before the leaves curl too tightly. If slugs appear after picking, spray with arsenate of lead.

GENERAL TREATMENT FOR PLUMS.

When to Spray.	*What to Use and What For.*
Early in the spring before growth starts.	Lime-sulphur wash for San Jose scale or European fruit scale, if present, the same as for apple.
Just before buds swell.	Bordeaux mixture for fruit-rot, leaf-spot and black-knot, with poison for curculio.
Immediately after the blossoms fall.	Bordeaux mixture for fruit-rot and leaf-spot with arsenate of lead for curculio. (For the Japanese varieties, dilute the bordeaux about one-half, or use self-boiled lime-sulphur mixture.)
Ten days to two weeks later.	Repeating the previous sprayings will tend to check the fruit-rot and curculio. This spraying should be repeated every 10 days or 2 weeks until there is danger of staining the fruit; stopping at least a month before picking time. On varieties especially susceptible to rot, an application of weak copper sulphate may be made about 2 weeks before ripening. No poison should be added. One pound copper sulphate to 150-200 gallons of water. *Black knot.*—At the annual pruning, cut out all knots. A careful inspection should be made in the early spring, and all knots cut out and burned. Cut back several inches below the knot. Wild cherry trees harbor the trouble and if near plum or cherry orchards should be removed, if possible.

GENERAL TREATMENT FOR VINEYARDS.

When to Spray.	*What to Use and What For.*
When the shoots are about 8 to 10 inches long.	Bordeaux mixture for black-rot.
Just before blooming.	Bordeaux mixture for black-rot, with poison for the grape-berry moth and rose-chafer.
Just as the blossoms fall.	Same as before.
About 10 days or 2 weeks later.	Bordeaux mixture and poison for black-rot and berry-moth. The need for this spraying depends upon the weather conditions and the amount of rot prevalent in the vineyard. If it is thought advisable to make later sprayings, some material should be used that will not stain the fruit.
	In vineyards where flea-beetles appear, Bordeaux and a strong arsenical poison just before the buds burst.
	In vineyards where the grape-berry moth is serious, spray in addition with bordeaux and an arsenical poison during the middle of July, before the 20th.
	For leaf-hoppers (sometimes, but incorrectly, called "thrip") tobacco water or kerosene-emulsion while the insects are young. (Burning rubbish late in the fall will destroy many hibernating leaf-hoppers.)

GENERAL TREATMENT FOR RASPBERRY, BLACKBERRY AND DEWBERRY.

When to Spray.	*What to Use and What For.*
Orange rust, determined by the bright, orange color on the under side of the leaves.	No method of preventing. Dig the plant as soon as discovered and burn.
Anthracnose, grayish spots on the canes and leaves.	Cut out and burn all canes after fruiting. Spraying may check the disease, but may not be profitable. If desirable, make first spraying when new canes are 6 to 8 inches high, and repeat twice about 2 weeks apart. Do not set diseased young plants.
	Cut out and burn borers in stem, gouty galls, and tree-cricket eggs.
"Worms" or "slugs."	Spray with an arsenical if fruit is just set, later use hellebore or pyrethrum.

GENERAL TREATMENT FOR CURRANT AND GOOSEBERRY.

When to Spray.	*What to Use and What For.*
Before growth starts.	Lime-sulphur wash for San Jose scale or European fruit-scale, if present. Cut out and burn wilted and hollow canes containing borers.
Just as the leaves are expanding, if worms appear.	Bordeaux mixture and poison, ¼ pound of Paris green or 2 pounds of arsenate of lead, to 50 gallons. Repeat if worms reappear before fruit is ¼ grown, if later, then use pyrethrum or hellebore.
	If leaf-bugs or aphids appear, spray with tobacco-water or kerosene-emulsion while the bugs are red and wingless, and before leaves become curled.
	Gooseberry-mildew. Where this disease is known to be serious, begin from the time the buds start and spray with potassium-sulphide, 1 oz. to 2 gallons of water, and repeat about every 10 days.

GENERAL TREATMENT FOR STRAWBERRY.

When to Spray.	*What to Use and What For.*
Young plantations.	Before setting the yong plants, pick off all diseased leaves and if root-lice are suspected, dip in strong tobacco water. After growth starts spray with bordeaux for leaf spot and poison for leaf curler, if present.
Fruiting plantations.	Spray with Bordeaux before blossoming and repeat 10 days or 2 weeks later. After fruiting, mow and burn over, if plantation is to be fruited again. If leaf-rollers have been present, spray with an arsenical after growth has started again, but before leaves curl.
	For strawberry root-lice, see bulletin 244, page 88.

GENERAL TREATMENT FOR THE POTATO.

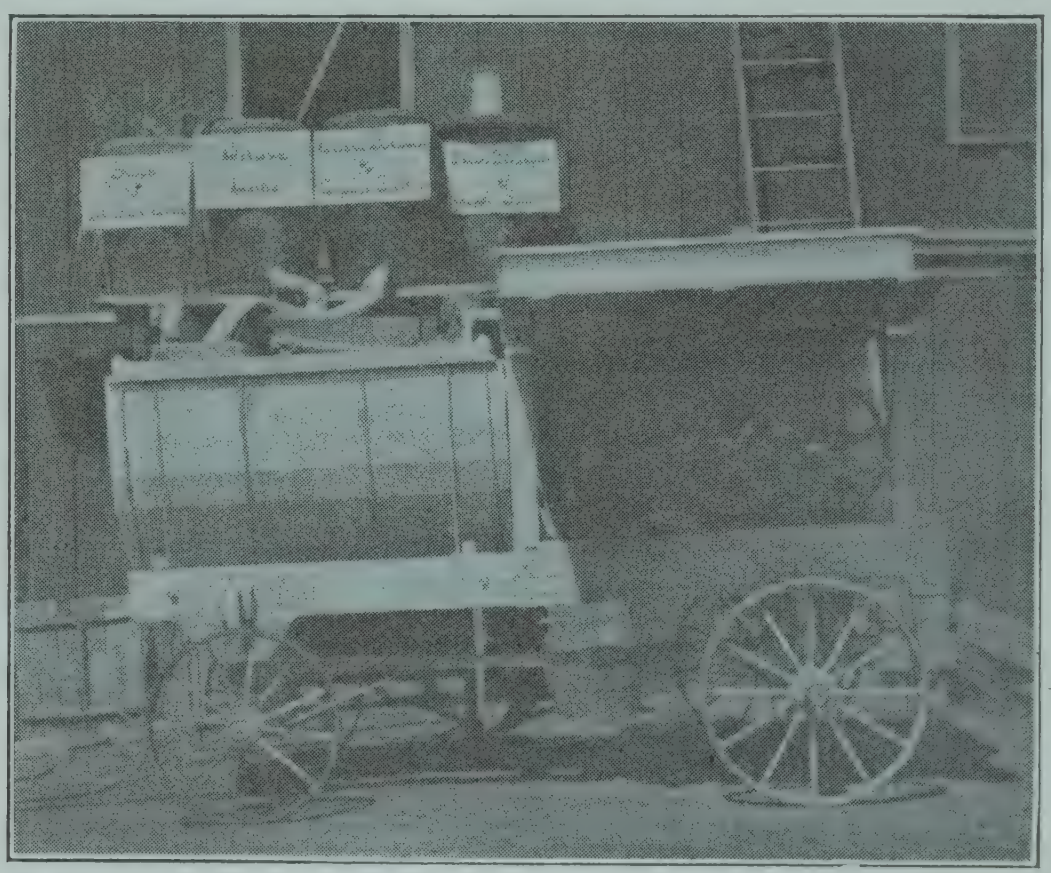
When to Spray.	*What to Use and What For.*
For scab.	Soak the uncut tubers for two hours in 30 gallons of water and one pint of formalin (can be secured of any druggist). This solution can be used several times. Do not put treated tubers back into crates or bags that held scabby potatoes. Make the treatment only a few days before planting if possible. Do not plant upon land that has recently grown crops of scabby potatoes or beets. When large quantities of potatoes are to be treated, formaldehyde gas may be used to advantage as follows:* "Place seed tubers in bushel crates or shallow slat-work bins in a tight room. For each 1,000 cu. ft. of air space in the room, spread 23 ounces of potassium permanganate evenly over the bottom of a large, flaring pan or pail placed in the middle of the room. Pour over this three pints of formalin. Close room at once and do not open for 24 or 48 hours."
For blight and "bugs."	Begin spraying with bordeaux mixture and poison when the "bugs" first appear, or when the plants are about 8 inches high, and repeat about every 2 weeks as long as the plants are growing. Spray often in warm, muggy weather; it is not as necessary in dry weather. Use bordeaux mixture (6 pounds copper sulphate and 4 or 5 pounds of lime to 50 gallons of water, and put in the poison, about ½ pound of Paris green or 2 pounds of arsenate of lead, or 1 quart of the stock solution of Kedzie mixture.

*From Bul. 149, Maine Exp. Sta.

FUNGICIDES.

BORDEAUX MIXTURE.

Bordeaux mixture is the standard spraying mixture used to protect plants from such fungous diseases as apple and pear scab, grape rot, leaf spots, mildews, potato blight, etc. There are but three things used in its preparation, water, lime and copper sulphate. The water acts as a carrier, the lime neutralizes the caustic action of the copper sulphate and also makes the mixture stick to whatever it is sprayed upon, and the copper sulphate is the chemical that prevents the growth of the spore of the disease.



These three substances are combined in various proportions, depending upon the kind of plant to be treated. For apples, pears, cherries and plums (except the Japanese varieties) the preparation is usually four pounds of copper sulphate, with about the same amount of lime, to fifty gallons of water. Poison is added as needed. The copper sulphate will readily dissolve in two gallons of hot water, to which should be added enough water to make twenty-five gallons or one-half barrel. Do not use an iron or tin vessel to dissolve this in, as the copper sulphate will destroy it, and besides the iron will spoil the bordeaux. A wooden pail is good. Slake the lime into a thin paste and add water to make twenty-five gallons. Pour, or let these run together into a third barrel,

and the bordeaux is made. When it is emptied into the spray barrel or tank, it should be strained through a brass wire strainer to catch any of the coarse particles.

Whenever it is necessary to use a quantity of the mixture, it is desirable to have the lime and the copper sulphate in "stock solutions." A quantity of lime is slaked to a paste and held so by being covered with water. The copper sulphate, say fifty pounds, is placed in a clean gunny sack and suspended in a barrel (one with wood hoops is much preferred) holding twenty-five gallons of water. This will dissolve in about a day. One gallon of this "stock solution"† is equal to two pounds of copper sulphate.

A good quick way to combine these three substances is as follows: Put the amount of the "stock solution" of copper sulphate required in a barrel, and add enough water to make 25 gallons, or one half barrel. Put about 7 pounds of the lime paste in a barrel and add 25 gallons of water, making a thin whitewash. Pour, or let these two run together into a third barrel, or directly into the spray barrel or tank, being sure to strain. When partly run in, test with ferro-cyanide of potash* to make sure enough lime has been used. If Paris Green, arsenate of lead, or any other poison is to be used, make it into a thin paste with a little water and add it to the bordeaux mixture, which is now ready to be used.

SELF-BOILED LIME-SULPHUR MIXTURE.

This mixture has come into prominence in the past few years and its chief value is that it does not (when properly made) injure peach or plum foliage and does not russet some varieties of apples as bordeaux-mixture does.

The formula is:

Lump lime	8 pounds.
Sulphur	8 pounds.
Water	50 gallons.

The mixture can be prepared better by using thirty-two pounds of lime, thirty-two pounds of sulphur, and eight or ten gallons of water, and then diluting to 200 gallons.

Place the lime in a barrel and add enough water to almost cover it, as soon as the slaking begins, add the sulphur, which should be run through a sieve to break up the lumps.

Stir constantly and add enough water to make a thick paste and then, gradually, a thin paste. As soon as the lime is well slaked, cold water should be added to cool the mixture and prevent further cooking. It is then ready to be strained into the spray tank, diluted up to the full formula, and used.

†Always stir this "stock solution" before dipping any out, in order that what is used may be full strength.

*This chemical can be secured of any druggist. Ten cents worth dissolved in a pint of water will be enough for a season. Drop a very little in the bordeaux, if a reddish, brown color appears, more lime must be added. If there is no discoloration, there is enough lime.

Care must be taken not to allow the boiling to proceed too far, if the mixture remains hot for fifteen or twenty minutes after the slaking is completed, some sulphur will go into solution and injury to the foliage may result.

The time of adding the cold water to stop the boiling depends upon the lime. With a sluggish lime all the heat in it may be needed, while with limes that become intensely hot, care must be taken not to allow the boiling to proceed too far.

STOMACH POISONS, FOR INSECTS THAT CHEW.

PARIS GREEN AND LIME.

Always use lime with Paris green, it makes the poison stick better, beside greatly reducing the danger of burning the foliage.

For spraying from a barrel, the writer has found the following method very useful,—Place from one-quarter of one-half pound of good lump lime, or unslaked lime, in each of three or four tin pails which will hold about three quarts or less. Old cans or crocks will answer just as well. Add enough hot water to slake it into a thin cream or paste. Now add to each lot, one-quarter pound of Paris green, previously weighed out, and placed in paper bags, stir while the lime is hot and allow to stand for some time. Now measure out about forty-four gallons of water in your spraying barrel, and make a mark that will show you how high it comes in the barrel, add the contents of one tin paid (viz., one-quarter of pound of Paris green and one-half pound of quick-lime slaked) into the forty-four gallons of water in the barrel. Stir well and spray. The pails or crocks can be used one at a time and refilled occasionally so that the stock is always on hand ready for use.

KEDZIE MIXTURE (ARSENICAL).

This mixture, originated by the late Dr. R. C. Kedzie, of this station, is cheap, but it has the disadvantage of lacking a warning color. It is a good substitute for Paris green, but must be made with care, and stored in well labeled jugs.

Dr. Kedzie in giving directions for its preparation says: "Dissolve the arsenic by boiling with carbonate of soda, and thus insure complete solution; which solution can be kept ready to make a spraying solution whenever needed. To make the material for eight hundred gallons (800) of spraying mixture, boil two pounds of white arsenic with eight (8) pounds of sal soda (crystals of carbonate of soda—'washing soda'—found in every grocery and drug shop) in two gallons of water. Boil these materials in any iron pot not used for other purposes. Boil for fifteen minutes or until the arsenic dissolves, leaving only a small muddy sediment. Put this solution into a two-gallon jug, cork tightly, and label 'Poison,' stock material for spraying mixture.

"The spraying mixture can be prepared whenever required, and in

the quantity needed at the time by slaking two pounds of lime, adding this to forty gallons of water; pour into this a pint of the stock arsenic solution. Mix by stiring thoroughly and the spraying mixture is ready for use. The arsenic in this mixture is equivalent to four ounces of paris-green.

"The pot, jug, etc., must never be used for any other purpose after using it for making this mixture."

If an additional pound or two of lime be added to the mixture, it will help to make the application permanent and conspicuous without in any way interfering with its effects. In using it the extra lime should be added.

ARSENATE OF LEAD.

This poison is coming into general use throughout the country, and has several advantages; it shows where it has been applied; and it does not easily burn the foliage.

Its action is slower than that of Paris green, but the fact that it does not readily burn the foliage is an advantage when spraying various kinds of delicate trees with one mixture. It is used at the rate of from one to five pounds to fifty gallons of water or bordeaux.

CONTACT INSECTICIDES, FOR INSECTS THAT SUCK.

KEROSENE EMULSION.

Place two gallons of ordinary kerosene in a warm place, either in a warm room or in the sun, and allow to become as warm as possible without danger from fire. Boil one pound of laundry soap or whale-oil soap in a gallon of soft water until completely dissolved. Remove the soap solution from the fire, and while still boiling hot, add the kerosene and agitate vigorously for ten minutes, or until the oil is emulsified, with a spraying pump by forcing the liquid back into the vessel from which it was pumped. When the liquid is perfectly emulsified it will appear creamy in color and will flow evenly down the side of the vessel when allowed to do so. Care should be taken to completely emulsify the oil and this is accomplished much more easily when the mixture is hot. This strong emulsion may now be readily diluted with water and used, or it may be stored away for future use. When cold it becomes like sour milk in appearance and should be dissolved in three or four times its bulk of hot water before diluting with cold water. If the water is at all hard, "break" it by adding a little sal-soda before putting in the soap.

Small amounts of this emulsion may be made by using the ingredients in small quantities but in the same relative proportion. It is used at the rate of eight or ten parts of water to one part of emulsion.

LIME-SULPHUR WASH.

This is a contact insecticide which should be used preferably just before growth starts, in any case, before the buds swell in the spring. If used when foilage is on the trees, the foliage will be killed. It is made in several ways, one of which is as follows:

Lump lime	20 pounds
Sulphur (flour)	15 pounds.
Water (hot) to make	50 gallons.

The lime is slaked with a small amount of hot water and the sulphur is sifted in, fifteen or twenty gallons of hot water is then added, and the mixture boiled. (It should take an hour or more of good boiling with frequent stirring.) When done the liquid should be amber colored and fairly clear. Strain, dilute with hot water to make (up to) 50 gallons, and apply warm, through a coarse nozzle.

If small quantities are required, use an iron kettle to boil it in. If larger quantities are to be used, live steam is preferable for boiling purposes, either in a tank or in barrels.

Applied just before the buds swell, it coats the branches in such a way as partially to hinder from settling down, such pests as the oyster-shell, scurfy scale, some aphids, and others.

HOME-MADE CONCENTRATED LIME-SULPHUR WASH.

The advantages in using the home-made concentrated lime-sulphur wash, are that a quantity of it can be cooked in advance and often at times when the actual work of spraying is not pressing, also when diluted it does not contain any sediment. The great disadvantage about it is that every lot cooked has to be tested with a hydrometer, to determine its strength, and then diluted accordingly. Several Experiment Stations, especially Pennsylvania[1] and New York,[2] have made experiments with various ways of preparing this concentrated wash but as yet no definite way has been found to make it of uniform strength or composition. The difficulty of getting a wash of uniform strength, apparently lies with the lime, which varies in composition and strength. Lime that contains more than five per cent of magnesium oxide and less than 90% calcium oxide does not combine in the cooking with the sulphur in a way to make a good mixture.

Lump lime	60 pounds.
Sulphur	125 pounds.
Water	50 gallons.

The lime is slaked to a thin paste and the sulphur is sifted in. Boil for one hour and stir frequently. Water enough should be added so that there will be fifty gallons at the end of the boiling.

After it is cooked if not to be used at once, it should be strained into

[1] Stewart, J. P., Penn. Station, Bulletin 92.
[2] Parrott, P. J., New York Station, Bulletin 320.

a barrel which should be air tight, as exposure to the air for any length of time causes the sulphur compounds to lose their value for spraying purposes. Each lot that is cooked up should be tested with a hydrometer when cooled and diluted according to the following table:[1]

Reading on hydrometer.		Amount of dilution. Number of gallons of water to one gallon of lime-sulphur solution.
Degrees Baume.	Specific gravity.	For San Jose scale.
35	1.3181	1 to 9
34	1.3063	1 to 8½
33	1.2946	1 to 8
32	1.2831	1 to 7¾
31	1.2719	1 to 7½
30	1.2608	1 to 7
29	1.2500	1 to 6¾
28	1.2393	1 to 6½
27	1.2288	1 to 6
26	1.2184	1 to 5¾
25	1.2083	1 to 5½
24	1.1983	1 to 5¼
23	1.1885	1 to 4¾
22	1.1788	1 to 4½
21	1.1693	1 to 4¼
20	1.1600	1 to 4
19	1.1507	1 to 3⅔
18	1.1417	1 to 3⅓
17	1.1328	1 to 3
16	1.1240	1 to 2⅔
15	1.1153	1 to 2½

The hydrometer is an instrument used to determine the weight and density of liquids. It is made of glass, is about one foot long, with a graduated scale on the side. It can be purchased from wholesale dealers in druggists' supplies, from Bausch & Lomb Optical Co., of Rochester, N. Y., or Whitall Tatum Co., Philadelphia, Pa. Directions for use should come with the instrument.

COMMERCIAL CONCENTRATED LIME-SULPHUR WASH.

There are several commercial brands of concentrated preparations of lime-sulphur wash on the market. The comparative value of each of these brands has not recently been tested by this Station, but many Michigan fruit growers report good success from their use.

HELLEBORE.

White hellebore is the powdered root of a plant. It kills both by contact and as an internal poison. It may be applied either dry or in the form of a liquid. When used dry it should be mixed with three or four times its weight of flour or of plaster and then dusted on the insects. Applied wet, one pound should be mixed with twenty-five gallons of water and this liquid applied as a spray.

[1] Parrott, P. J., New York, Bulletin 320, p. 434.

Hellebore is especially useful against all moist-bodied insects, such as currant worms, pear and cherry slugs, etc., for the poison sticks to the bodies.

INSECT POWDER, BUHACH, PYRETHRUM.

This valuable remedy has one drawback, its cost. It is too expensive for use on a large scale. It kills insects through their breathing pores, but is harmless to man and beast. It will kill many of the insects of the garden if dusted on or applied as a spray at the rate of one ounce to two gallons of water.

Use the powder when it is undesirable to use poison, but never buy any unless it comes in tightly sealed packages. It loses its strength on short exposure to the air. An hour will suffice to weaken it. It must be applied from time to time, as it quickly loses its strength.

TOBACCO.

Tobacco in the form of dust may be obtained of the large manufactures at a few cents a pound.

It is useful in destroying root-lice, especially woolly-aphis, in young trees, and in keeping insects from garden truck. For root aphis, incorporate four to six handfulls of tobacco dust into the soil about the roots and induce a thrifty, healthy growth by using liberal quantities of nitrate of soda or barnyard manure early in the spring.

A strong infusion or tea made of waste will kill plant lice if sprayed when they first appear.

HYDRATED LIME.

Finely slaked lime is often useful because of its slight caustic properties. Against such larvae of saw-flies and beetles as are sticky, for instance those of the cherry-slug and asparagus-beetle, it may be used as a substitute for poison, if the latter, for some reason is undesirable.

Stone lime may be shaked with a small amount of hot water, using just enough to turn it to a dry powder. Such slacked lime is as fine as flour and very soft to the touch, having very little grit. Use a metal pail or kettle to slake in, as the heat may set fire to wood. Do not use too much water, and where possible, use freshly burned lime.

Hydrated lime may be used in making Bordeaux mixture, but it is not as reliable as good, fresh, lump lime. It is less adhesive, not as strong (so more should be used) and more expensive. The one advantage is that it is a little easier to use.

Ground lime for making Bordeaux mixture acts exactly like lump lime, if fresh, but this is difficult to determine as it is already in a powder.

CAUTIONS.

Do not spray while plants are in bloom. It is prohibited by law, except when canker-worm is present, and may destroy bees and other beneficial insects.

Do not dissolve copper sulphate in an iron or tin vessel. It will ruin the vessel and spoil the spraying solution.

For all spraying solutions containing copper sulphate, the pump must be brass or porcelain lined.

Wash out pump and entire outfit each time after using.

Use arsenate of lead on stone fruits in preference to other forms of arsenical poisons. It is less liable to burn the foliage.

Do not spray fruits or plants with poison within a month or more of the time when they are to be picked.

Keep all "stock solutions" covered to prevent evaporation.

FOREWORD.

Special Bulletin No. 52.

Heretofore the progress and results of experimental work of the Upper Peninsula Sub-station at Chatham have been printed in the form of annual reports with one exception. These reports have contained a large amount of data concerning field, orchard and garden crops, relating chiefly to variety testing and cultural methods. This publication is the first of a series, each number of which will deal solely with some particular crop or groups of crops such as are by nature closely associated. In these publications a special effort will be made to furnish detailed information of a practical character as an aid to the farmer. The investigations of the Sub-station have been extended and repeated sufficiently since its organization to make the results a safe basis for conclusions and recommendations relative to farm practices.

A large number of the first annual report of the Upper Peninsula Station for the year 1900 is still on hand. This report includes the law relating to the establishment of the Station, in addition to reports of the superintendent, as well as the preliminary findings of those who made the initial investigations relating to the geological, botanical and entomological conditions surrounding the Station. Copies may be procured upon request without charge.

R. S. Shaw, Director.
East Lansing, Michigan.

CORN PRODUCTION IN THE UPPER PENINSULA OF MICHIGAN.

By L. M. Geismar.

HISTORY.

It is commonly believed that corn cannot be successfully grown in the Upper Peninsula of Michigan. To the extent of not being able to ripen the principal varieties grown in latitudes farther south, at least as far as the greatest portion of the Upper Peninsula territory is concerned, this belief is well founded and has been confirmed by the early investigations of the Experiment Station at Chatham. Later tests have demonstrated that the Dakota varieties of corn speedily adapt themselves to Upper Peninsula conditions, growing somewhat taller, probably because of the more abundant rainfall. It is not generally known that corn has been successfully grown in the Upper Peninsula, probably long before Columbus discovered America and by at least two tribes of Indians, the Ottawas and the Chippewas, who controlled that portion of country lying between the St. Mary's river on the east and the Escanaba and Chocolate rivers on the west. In his Relation for 1669-70 the early explorer and missionary, Father Dablon, mentions the fact "That the Ottawa squaws, in digging holes in the sand to hide their corn, often find masses (of copper) weighing 20 or 30 lbs."* In May, 1671, Father Allonez, before a grand council of Indian chiefs assembled at Sault Ste Marie, pronounced a panegyric on the King of France, during which he said, "You think yourselves very rich when you have ten or twelve sacks of corn and hatchets, and kettles, and other things of the kind."* It is quite certain that the corn thus referred to is the same variety which is still being grown in a small way in the neighborhood of Sault Ste Marie, in Chippewa county, the seed having been secured from Indians over half a century ago by the father of J. M. Ryan of that city. While considerably hybridized at present, this corn, a Flint variety, is still found occasionally as pure-bred, and as such is readily distinguished by its peculiar satiny luster and its bright straw color.

VARIETIES.

Inasmuch as very little of the "Ryan" corn is available and the variety is rather dwarf in size, and inasmuch as other varieties are apt to meet with total or partial failure when first introduced, the Upper Peninsula Experiment Station is endeavoring to acclimate several desirable varieties by selection for earliness and by breeding new varieties. The Station's area of cleared land suitable for corn growing is still small,

*Report on the geology and topography of a portion of the Lake Superior land district. Congressional report No. 69, 31st Congress, May, 1850. Part 1, pages 9-11.

hence there is difficulty in keeping the varieties from becoming hybridized, and the process of propagating pure-bred varieties has been correspondingly slow. The success thus far obtained by the Sub-station and the historical facts above related warrant the prediction that corn may be as successfully grown in the Upper Peninsula as any other grain crop.

Dakota White Flint and Gehu, a Yellow Flint, were first secured in 1904, as was also the Golden Dent, the seed of which was kindly furnished by the North Dakota Experiment Station. Owing to late planting, only a few ears ripened, but enough seed was saved for further propagation, and since 1905, the two Flint varieties have ripened completely each year, yielding during the five years at the rate of thirty-two to sixty-one bushels of shelled corn per acre. Special selections of the Gehu variety have been made since 1906, and the size of stalk and ear has been materially improved since then. By selecting the best of the earliest ripe ears, the time between planting and maturing has been materially shortened, and of this selected type the Station has started to distribute seed throughout most of the Upper Peninsula counties. About 130 two to four-ounce packages were distributed in 1909, and about 250 will be distributed in 1910. The Golden Dent is not sufficiently acclimated as yet for general distribution, but the Station distributed some seed in 1905 throughout Menominee county, and this variety is now successfully grown there. The rapidity with which corn will adapt itself to varying conditions of climate was tested in 1906, when seed of this variety which had ripened the year before in Menominee county was planted at the Station along side of seed of the same variety which had ripened at the Station. When full grown, the stalks from the Menominee county seed were eighteen to twenty-four inches taller and the ears were considerably larger, but while sixty per cent of the ears from the Station seed reached full maturity, only ten per cent ripened from the Menominee county seed.

Another and somewhat darker colored Golden Dent was secured in 1906 from M. S. Joiner of Benzonia, Michigan, and has been successfully propagated since then by the Experiment Station. This variety is now nearly acclimated and will soon be ready for general distribution, having ripened successfully during 1909 in Marquette county, where a small amount of seed was distributed for the first time. With the recent expansion of the dairy business and the consequent building of silos, there has come a demand for taller growing varieties suitable for winter ensilage. Quite a number of such varieties have been tested at the Experiment Station during the past five years, and of these the two which have proved most satisfactory are Minnesota No. 13, which has reached a height of eight to nine feet and ripened well during two seasons, and Golden Ideal, with height ranging from nine and a half to eleven feet and the ears generally reaching the glazing stage.

SOILS.

While it has thus been shown that the question of variety is of prime importance, the question of soil and of cultural methods is of almost equal importance, more so, at least, than it is in southern regions. Muck soils, bottom lands and heavy, clay soils should be avoided. Good air

drainage is an important factor, hence corn should be planted on high and slightly rolling ground. It should be a sandy loam or a well drained clay loam.

PREPARATION OF SOIL.

In the central and northern parts of the Upper Peninsula fall plowing will generally give better results owing to the fact that the ground seldom freezes and that a greater amount of moisture may thus be stored up in the subsoil. In the southern part, where the ground generally freezes more or less and the snow disappears earlier, early spring plowing will probably give as good results as fall plowing. Fall plowing is essential, however, in the case of sod ground of long standing and regardless of latitude for it helps to destroy a great number of cutworms, wireworms and the larvæ of the May beetle.

ENRICHING THE SOIL.

The plowing under of a clover sod or of coarse manure, or of both, is highly recommended. It may be done early in the spring, for since planting need not begin until the latter part of May, there is ample time left for a thorough preparation of the seed bed. The plowing under of such coarse material hastens the growth of the corn plants.

The following experiments were made in 1905 and again in 1906. On the plot upon which clover and manure were plowed under in 1905, the variety Gehu tasseled out July 28th, the stalks when full grown averaged forty-nine inches high and the yield of shelled corn was at the rate of 31.82 bushels per acre. Where manure only was plowed under, the tasseling began August 3rd, the height of the stalks averaged forty-seven inches and the yield was 28.28 bushels per acre. On the check plot the tasseling began August 6th, the stalks averaged forty-three inches and the yield was 22.09 bushels per acre. In 1906 the difference in the time of tasseling was much less and ranged from one to three days only, while the difference in the height of the stalks and in the relative yields was correspondingly smaller. The fact that there was again a difference, however, merely emphasizes the value of methods for hastening the growth of the young plants and of utilizing every heat unit to the best advantage, for with hardy varieties to begin with, this may well be considered the keystone of successful corn growing in the Upper Peninsula.

PLANTING AND CULTIVATING.

Light and heat being next in importance, the best results will invariably be secured from planting in checks and cultivating both ways. The distance between rows in check-rowing should not be less than three and a half feet for early maturing Flint varieties, nor less than four feet for early Dent varieties which average seven to eight feet in height. Inasmuch as the taller varieties of corn grown for silage cannot be expected to ripen every year, it is highly desirable for the sake of quality to avoid the common method of drill planting which permits cultivating lengthwise of the rows only. With stalks far enough apart to allow cultivating both ways, the crop will come nearer to maturity, and what

it will lack in quantity will be more than made up in quality. The shading of the plants is thereby reduced to a minimum, and the better results will come from the greater amount of sunshine which is thus provided as well as from the more intensive cultivation.

Planting should be done early, remembering that a severe frost during the late spring is less injurious to corn than a light frost during early fall. About May 25th has been found to be the best time for planting during ordinary seasons in the central portions of the Upper Peninsula and at elevations of 750 to 900 feet. At lower altitudes and near the lake shores planting can safely begin five days to a week earlier, and should be delayed until about June 1st in locations with an altitude of 1000 feet and upwards.

Cultivation should begin early and continue just as long as it can be done without injury to the plants. It should be kept up at least once every ten days and oftener during a period of dry weather.

The harvesting of plants need not be hastened unduly should they be slightly damaged from frosts, for the damage, even in the case of severe frosts is supposed to be mostly confined to the loss of water, and this can be added in varying amounts while filling the silo.

FOREWORD.

Special Bulletin No. 53.

Recent ravages of grasshoppers in grain fields, meadows, gardens and even lawns in parts of the Upper Peninsula have attracted some attention and for this reason the present bulletin is timely and likely to be of much value. While it is almost impossible to foretell outbreaks of grasshoppers, they are at present established in force in parts, at least, of the Upper Peninsula and are reasonably likely to continue in possession for a time. The injury last season and the season before was done largely by the Pellucid locust, *Camnula pellucida,* accompanied by the lesser migratory locust, *Melanoplus atlanis,* and by a few of the red-legged locust, *M. femur-rubrum.*

R. H. Pettit, Entomologist.

East Lansing, Michigan.

GRASSHOPPERS AND THEIR CONTROL.

BY L. M. GEISMAR.

Considerable damage to grass and oats has been done by grasshoppers during the past two seasons in those portions of the Upper Peninsula where soils of a sandy nature predominate. As much or more damage may be anticipated this summer should the weather be as dry as it has been during the seasons of 1908 and 1909 and no effort be made to kill the grasshoppers. This warning is given because of a widespread local belief that nearly all grasshoppers were killed, during the late summer of 1909, by "red lice" which were found on the under wings of nearly all grasshoppers. These red lice are the young of a very small crimson-colored mite commonly called "Lucky Spider" and resembling a little chip of bright velvet. They appear very early in the spring crawling about or hiding under clods, and while they undoubtedly weaken the hopper, it is likely that few are killed outright by the mites. Numerous grasshoppers with these parasites on their wings or bodies were found to be laying eggs last season as early as the latter part of July and as late as the latter part of September.

Much more benefit can be expected from the ash-grey blister beetle, an insect locally called a "new potato bug" which has been multiplying very rapidly during the past two seasons, feeding when full grown upon potato leaves, clover, alfalfa, beans and many other plants both wild and cultivated. While in their larval stages the beetles live upon grasshopper eggs, and in this regard Professor R. H. Pettit, Entomologist of the Michigan Experiment Station, states, "In fact, the young blister beetles of this group are not known to feed on anything else. The fact that the eggs of grasshoppers are laid in pods covered with water-tight shells, and containing from twenty to thirty eggs, makes it possible for the beetles to do a great deal of damage to the contents of the pods by devouring part of the eggs. If all are not eaten, fermentation and the consequent loss of the rest of the batch are sure to follow. From this we see that it is possible for the beetle to attain its majority only at the expense of many grasshopper eggs." We may therefore expect that blister beetles will be numerous during the coming season and that if they eventually kill off most of the grasshoppers they will themselves rapidly decrease in number because of the scarcity of their natural food.

The so-called "Hair snake," a greyish or white thread-shaped worm resembling a horse hair and found frequently in pools of water, is a parasite which lives for a part of its existence inside the body cavities of grasshoppers and crickets. Though man allows the wanton destruction of birds which are helpful in destroying grasshoppers and other injurious insects, nature thus provides other natural enemies to hold in

check and finally subdue insect plagues. The process is slow however, and the damage to cultivated crops is meanwhile correspondingly large if no measures are taken for a more prompt restoration of balance between injurious and beneficial insects.

Wet seasons, in the case of grasshopper outbreaks, are far more effective, for the insect becomes sluggish during long spells of wet weather and is either killed by disease or becomes an easier prey to its natural enemies.

ECONOMICAL AND EFFECTIVE REMEDIES.

While grasshoppers feed on low or wet ground, as well as on high ground, they prefer dry locations and remain there as long as food of some sort is abundant. On a high, sandy stretch of land within two miles of the Station, grasshoppers, in 1908, after destroying hay and nearly all other crops except potatoes and peas, peeled the bark off every elderberry bush within sight before they moved on to lower ground where there was an abundant and varied food supply. Likewise grasshoppers thrive best during the dry, hot, sunshiny weather and lay their eggs invariably in well drained or fairly sandy soils and at a depth of one-half to one inch. Fall plowing sandy soils wherever it is possible offers, therefore, an excellent remedy by burying the egg pods, thus preventing them from hatching, by breaking open some, so that moisture can get in and leaving still others near the surface where birds or shrews can get them.

Of other remedies which are generally recommended, this Station finds the use of the Criddle mixture safe and, at the same time, the cheapest method for the wholesale destruction of grasshoppers. Although tested rather late during the past season and at the time when the grasshoppers were two-thirds or more grown, the effectiveness of the mixture has been demonstrated both on the Station grounds and on a twenty-acre timothy meadow about two miles east of the Station where in 1908, the grasshoppers had destroyed the crop together with the hay and oats crops on several other farms in that neighborhood. When the mixture was tested the grasshoppers had already destroyed a strip of grass from two to six rods wide on the south and east sides of the twenty-acre field and nearly as much on the other two sides. About a week after the mixture had been applied the number of live grasshoppers was found to be strikingly small, and an inspection of the premises after the hay was cut showed that the ground was literally covered with dead grasshoppers. Neighboring farmers who came to watch the progress of the experiment subsequently obtained similar results on their own farms and the remedy proved equally effective when later on great swarms of grasshoppers made their appearance on the Station grounds. The results indicated that practically all damage can be avoided by applying the mixture earlier, say during the fore part of June when the grasshoppers are still quite small.

CRIDDLE MIXTURE.

Criddle mixture is horse manure mixed with salt and Paris green. It has been in more or less general use for some years, notably in Canada, the home of its originator. The fondness of grasshoppers for anything which contains salt is well known, for they will eat paper which has been wrapped around salted butter, and in order to get at the salt which has been deposited with the perspiration, they will chew up old coats or much worn caps, and roughen the handles of forks, hoes or hand rakes which are left out doors. To prepare the mixture, take about one hundred pounds of horse droppings, two pounds of salt and either one pound of Paris green or three pounds of arsenate of lead. If no large scales are handy, five ten-quart pails may be taken as one hundred pounds. Mix the poison in a half pailful of water and stir all the ingredients well in a barrel or watertight box, gradually adding another pailful of water to facilitate mixing. It is best to use only clear horse manure which is free from straw or other litter. A large shovelful has been found sufficient for about every two rods square, and if grasshoppers are found to invade a field from one side only, the field will be sufficiently protected by depositing shovelfuls about a rod apart on that side of the field only. To prevent rapid drying and scattering by the wind the mixture should be applied in heaps of one shovelful each and in a well moistened condition. On the above mentioned twenty-acre field, the grasshoppers came in from all directions and the mixture was used on all four sides as well as at the base of a few stumps in the middle of the field. The cost for the twenty-acre field was $1.30 for the poison and salt, or six and a half cents per acre exclusive of labor. Three hours work mixing at 15 cents per hour and three hours time of one man and a horse at 30 cents per hour would be a fair allowance for labor and would amount to $1.35 for the area of twenty acres or an average of 13¼ cents per acre for material and labor combined.

As the result of careful observations at the Upper Peninsula Station no losses among poultry or wild birds exposed to the Criddle mixture or poisoned grasshoppers were noted. As no actual tests have been made in the case of farm animals, judgment should be exercised in exposing them to the Criddle mixture at least until it has been conclusively proven that there is no danger.

FOREWORD.

Technical Bulletin No. 2.

The investigations on the "Keeping Qualities of Butter" reported in this bulletin have been a continuation of the work of last year. Technical Bulletin No. 1 aimed at a general study of the field as a basis for more special studies; this bulletin has placed the stress upon certain specific factors, primarily salt and proteins. These have been attacked in the light of the influence of salt upon microbial life and the changes wrought upon the proteins by micro-organisms, in reality, assuming in the plan of studies that micro-organisms are responsible for most of the changes in butter.

While the results conveyed in this bulletin are not conclusive, they are, indeed, an advance upon our present knowledge, and we hope that, ultimately, the results will be so decisive as to provide the butter-maker with the proper weapons to overcome his difficulties in manufacturing.

CHARLES E. MARSHALL.

INTRODUCTION, IN WHICH THE PRESENT STATUS OF THE CHANGES IN BUTTER DURING COLD STORAGE IS CRITICALLY DISCUSSED.

Meats of all kinds, as beef, fish, chicken, and many other food substances, if kept above the freezing point, will begin to deteriorate after a short time; butter, under the same conditions, becomes rancid. Below the freezing point, meat and similar foods will keep for a year or more (which is not in strict accordance with M. E. Pennington), while butter may not keep; it becomes rancid sooner or later. Meat is changed by bacteria and similar micro-organisms. Butter kept above the freezing point becomes rancid through the action of micro-organisms, since butter containing sufficient antiseptic keeps. How butter changes below the freezing point has not been definitely settled. It may be that some micro-organisms are able to act even under the unfavorable conditions of salted cold storage butter or that the changes taking place are of a purely chemical nature.

Both suppositions have their strong and weak points. The theory that the deterioration of butter is due to a purely chemical change, at least so far as fishy flavor is concerned, has been taken up recently by L. A. Rogers. In his opinion, "fishy flavor is caused by a slow, spontaneous chemical change to which acid is essential and which is favored by the presence of small amounts of oxygen," and, "Fishy flavor may be produced with reasonable certainty by overworking the butter made from sour cream." He also states, "In all cases in which the records were complete it was found that those experimental butters which became fishy were made from high acid cream. Fishy butter was made from cream acidified with lactic and acetic acids. *However, cream with high acidity does not uniformly develop fishiness.*"

In a later publication of Rogers and Gray, it is stated that the writers do not exclude the action of bacteria as a factor in causing changes taking place in butter. The uniform deterioration of the high acid butter at the lower temperatures, however, could not be accounted for in this way.

There are several facts in favor of the chemical explanation. The spoiling of butter at as low temperatures as -10° F. (-23° C.) can hardly be accounted for by micro-organisms; it seems impossible that bacteria can still be active at such low temperatures. None of the bacteriologists working with cold storage butter have ever succeeded in finding a typical micro-organism regularly present in large numbers, as Jensen did with rancid butter at room temperature. Churning experiments with those few bacteria frequently found gave negative results. Furthermore, Rogers, and Rogers and Gray succeeded in produc-

ing a very poor keeping butter by adding lactic, acetic or hydrochloric acid to pasteurized cream, the bacteriological examination of the cream showing only an insignificant development of bacteria.

But there are also several facts hardly explicable by chemical changes alone. The general experience of butter dealers that sour cream butter (of course, not from over-ripe cream) keeps better than sweet cream butter has to be taken into consideration. The experience of Rogers that "frequently butter made from cream with a high acidity showed no trace of this (fishy) flavor," is a strong point against the chemical theory. The paper of Rogers mentions only four lots of butter which are in favor of his theory; how many more experiments turned out in favor of the chemical theory and how many against it, is not said. If, however, the fishy flavor were due to a chemical oxidation favored by lactic acid, or to a similar process, we should expect it to occur in *all* sour cream butters, since the factors concerned,—fat, curd, acid, water, oxygen—are all present.

If butter deteriorated at as low a temperature as —20° C. by a chemical process, we should expect it to deteriorate very much faster by the same process at room temperature. But butter at room temperature, treated with antiseptic, keeps (Reinmann). Another fact can hardly be explained by the chemical theory alone, namely, the experience of butter dealers that light salted butter keeps better than unsalted or high salted butter. This can be accounted for by the bacteriological theory, as we shall discuss later.

The bacteriological theory, also, has some points in its favor and others against it. The experience of Reinmann that butter sterilized, either by heating or treating with an antiseptic, keeps, is in its favor. Also, the statement of Rogers just mentioned, that sour cream butter often, but not always, becomes fishy, favors the theory in that certain micro-organisms, or the combination of micro-organisms causing this undesirable flavor, may be present in some creams and absent in others. Again, micro-organisms in the cream and butter that have increased to large numbers before encountering the salt or cold, may have produced enzymes or similar substances by which the decomposition is brought about. These enzymes may be less affected by the salt added to the butter or by the temperature of the storage than the bacteria themselves.

Against the theory, is the fact that salt and cold check or stop the multiplication of micro-organisms and make the conditions unfavorable for their existence. Multiplication is not absolutely necessary because bacteria may work without multiplying. And, too, we know that certain micro-organisms can withstand salt. By our present methods of determining micro-organisms quantitatively the only organism that is found in butter or cheese regularly in large numbers is the *Bacterium lactis acidi;* but the changes which occur in butter or cheese are different from those occurring in pure cultures of this bacterium. We must assume either that we are dealing with micro-organisms unrevealable by our present methods, or that our knowledge of the physiological processes of *Bacterium lactis acidi* is very limited.

Another fact against bacterial action is the result of the investigations of M. E. Pennington concerning the cold storage of chickens. These kept fairly well for about one year, but after two years they were very

badly decomposed, and after three years, quite unfit for consumption The deterioration was not a real putrefaction, and from all appearances, not caused by micro-organisms. It seems that organic substances of a certain nature may undergo a decomposition with a production of disagreeably smelling substances without the presence of bacteria. The actual absence of bacteria has not been proved.

OUTLINE OF INVESTIGATIONS.

THE INFLUENCE OF SALT.

Freezing does not kill bacteria. It only prevents them from multiplying and from decomposing substances. This is not directly due to the low temperature. The lower the temperature the slower the development, but many bacteria do multiply even below the freezing point, so long as the liquid is not frozen. Freezing makes the medium solid and the bacteria, having no body temperature of their own to thaw the frozen food material, are cut off from their food supply. The effect of the freezing resembles that of drying—it takes away the water— but as soon as the medium melts, the micro-organisms begin to multiply again. Meat, chicken, fish, fruit juice like cider, and similar substances, are frozen solid in most cold storages.

Not so with butter. The salt in butter, about 2% to 4% for about 15% mosture, gives a brine of 12% to 26% salt since the salt dissolves in the water only and not in the fat. The freezing point of this solution is so low that in the ordinary cold storage it remains liquid. There is a chance for micro-organisms to develop, at least, to cause deterioration. If we do not salt the butter, it seems probable that the buttermilk in it would freeze and thus cause the butter to keep.

This consideration led us to the experiment discussed in this paper. We obtained salted and unsalted butter from three creameries, and kept one tub of each of these samples in a large cold storage plant at —6° C. (21° F.) and another tub in the cold storage at our laboratory at +6° C. (43° F.). From these twelve samples, we made frequent bacteriological and chemical determinations.

The bacteriological investigations of last year's preliminary work showed no increase of any bacterium, nor any characteristic species regularly present in butter which had any evident relation to its keeping qualities. We continued the experiments, however, in order to ascertain if an increase of some species could not be noted, at least, in the first weeks of storage. We also kept plates at +6° C. to give those bacteria accustomed to lower temperatures a chance to grow; besides, we made plates from salted agar—the salt concentration corresponding to the brine concentration in the butter sample. This gave us an idea of what kinds of micro-organisms were able to multiply in salted butter.

THE PROTEID DECOMPOSITION.

The chemical investigations aimed mostly at the decomposition of protein. Our previous investigations showed, in most cases, no increase in the acidity of butter kept below freezing point, while above freezing point, in all samples the acidity increased. Only 24 samples out of 96 placed in cold storage had an increased acidity and this increase was high in two samples only. Nevertheless, most of these samples were rancid, and we had butter without the slightest increase of acid which scored "very rancid." We have stated in our first publication that other investigators have questioned whether there is a direct relation of free acids to the rancid taste of butter.

There has never been described a bacterial decomposition of fat which did not begin with the hydrolytic action, i. e., with the production of glycerin and free acids. Therefore, it seems quite plausible that the fat of the samples mentioned above had not been decomposed at all. If it is not the fat, there is practically nothing but casein left as the origin of the substances which cause the disagreeable odor and flavor of rancid butter. This is not at all improbable, for proteins are most apt to give objectionable-smelling decomposition products. It is surprising that, as far as we know, bacteriologists and chemists, experimenting with rancid butter, never paid much attention to the casein. Of course, there is not very much protein in butter, only about 0.5%, but the slightest trace of aromatic substances is sufficient to give a distinct odor and flavor. The practical buttermaker knows very well that the butter must be washed, for otherwise it does not keep well. He also knows that the working of starter into butter gives a poor keeping product, though it may have the fresh starter flavor for a short time.

Another fact indicates the possible influence of protein decomposition upon the rancid taste of butter; Jensen found in his experiments that butter kept at room temperature is made rancid by the pure cultures of Oidium lactis, Cladosporium butyri, Bacillus prodigiosus and Bacillus fluorescens liquefaciens. All of these micro-organisms are well known for their rapid decomposition of proteins. It seems quite probable that the rancid taste of butter kept above freezing point is due partly to the free fatty acids and partly to some casein cleavage products.

The indications for a proteid decomposition being so strong, we thought it worth while to make some investigations along this line.

THE COLLECTION AND STORING OF SAMPLES OF EXPERIMENTAL BUTTER.

For this work there was obtained from a single churning four 30 pound tubs—two with salt and two without salt—from each of three different creameries. One of the salted and one of the unsalted samples from each lot were placed in the laboratory storage at +4° C. to +10° C., the other two in a Lansing cold storage which maintained a temperature of —4° C. to —6° C. A member of the laboratory staff visited the creamery at the time the samples were churned, observed the creamery

conditions and secured directly from the churn small average samples of both the unsalted and the salted butter. From these samples, which were taken to the laboratory without delay, were made the first bacteriological and chemical analyses.

DETAILS OF MANUFACTURE.

Creamery A.

Samples Nos. I, II, III and IV.—The creamery was small and crowded, and the conditions under which this butter was made were exceedingly unfavorable. A mixture of gathered cream and whole milk cream was ripened for 48 hours (over Sunday) with Erickson's starter which had been carried on for two weeks in pasteurized skimmed milk. Churning began at 52° F. and continued for twenty-eight minutes; the buttermilk was 60° F. The butter was washed once with water (from a 180 ft. driven well) at 58° F., and, after the water was allowed to drain off, tubs Nos. II and IV were filled with butter. The rest of the butter was worked with brine, allowed to stand in the brine for an hour and a half and worked again. The brine was drained off and a portion of the butter was filled into tubs Nos. I and III. Shipment took place immediately, but the tubs could not be removed from the freight depot until about twenty-four hours after arrival. Thus, these samples stood for about twenty-six hours at a rather high temperature before going into storage. Six hours after churning, the first examinations were begun.

Creamery B.

Samples Nos. V, VI, VII and VIII.—The creamery and apparatus seemed to be well kept. The cream for these samples was separated at the creamery from the night's and morning's milk and ripened in covered vats at about 70° F. for about three hours, then cooled to 52° F. and allowed to stand for about sixteen hours, during which the temperature raised to 57° F. The third transfer of a commercial starter, which was carried in pasteurized selected whole milk was used in the ripening. Churning began at 57° F., and the buttermilk, when drawn off, was 60° F. The butter was washed with water (from a driven well) at 61° F. by filling the churn about half full and rotating. The water was drained off and samples Nos. VI and VIII were taken out. Dry salt was worked into the rest of the butter by rotating the churn, and the water and buttermilk thus worked out were allowed to drain off; then samples Nos. V and VII were taken. The four tubs were shipped about an hour and a half after churning, and, about eight hours later, tubs Nos. VII and VIII were placed in the Lansing cold storage and Nos. V and VI in the cold storage at the laboratory. The first analyses, both bacteriological and chemical, were begun about eight hours after churning.

Creamery C.

Samples Nos. IX, X, XI and XII.—The creamery was an old building, but the rooms and apparatus were well kept. The gathered cream which was brought in at various times during the day was rather sour

when it arrived at the creamery. It was cooled immediately to 60° F., ripened naturally without pasteurization or starter, then cooled to 50° F. and kept over night. Churning, which began at 50° F., lasted for forty minutes. After washing the butter twice with city water—first at 61° F., then at 58° F.—samples Nos. X and XII were collected. The rest of the butter stood with dry salt for about half an hour, then it was worked a little and filled into tubs Nos. IX and XI. The samples were shipped by express and placed in storage—Nos. IX and X at the laboratory and Nos. XI and XII in Lansing—about ten hours after the tubs were filled. About seven hours after churning, the chemical and bacteriological investigations were begun.

THE SCORING OF SAMPLES.

The three lots of butter were not made at the same time, since the bacteriological and chemical investigations in the first few days of storage would not permit us to handle all samples at once. Therefore, there is a difference in the age of lot A and lot C of three weeks. As we did not wish to have the butter scored until all samples were together, the first score was made September 11th, when lot A had been

TABLE NO. I.

The Butter Scores.

Sample.	Information.			Flavor.										Notes.			Score.
	Salted.	Unsalted.	Age when scored.	Old cream.	Over-ripe.	Rancid.	Oily.	Oystery.	Cheesy.	Aged.	Feverish.	Unclean.	Dish rag.	Too much salt.	Too little salt.	Mottled.	
No. III	+	....	24	+	....	....	....	....	....	....	....	....	....	....	....	....	93
No. III	+	....	88	+	....	....	....	+	....	....	+	....	....	....	....	....	89
No. III	+	....	290	....	....	+	+	+	....	....	....	....	....	....	+	+	82
No. IV	....	+	24	+	+	....	....	....	....	....	....	....	....	....	....	....	92
No. IV	....	+	88	+	+	....	....	+	....	....	....	....	....	....	....	....	84
No. IV	....	+	290	....	....	....	+	+	+	+	....	+	....	....	....	....	71
No. VII	+	....	11	+	....	....	....	....	....	....	....	....	....	....	....	....	93
No. VII	+	....	75	....	+	....	....	+	....	....	....	....	....	....	....	....	91
No. VII	+	....	277	....	....	+	+	+	....	+	....	....	+	....	....	....	84
No. VIII	....	+	11	....	+	....	....	....	....	....	....	....	....	....	....	....	91
No. VIII	....	+	75	....	+	....	....	+	....	....	....	....	....	....	....	....	90
No. VIII	....	+	277	....	....	....	+	+	....	+	....	+	+	....	....	....	73
No. XI	+	....	3	....	....	+	+	....	....	....	....	....	....	+	....	....	89
No. XI	+	....	67	+	....	+	+	+	....	....	....	....	....	+	....	....	87
No. XI	+	....	269	....	....	+	+	+	....	+	....	....	....	+	....	....	79
No. XII	....	+	3	+	....	+	+	....	....	+	....	....	....	....	....	....	90
No. XII	....	+	67	+	....	+	+	+	....	+	....	....	....	....	....	....	84
No. XII	....	+	269	....	....	....	+	+	....	+	....	+	....	....	....	....	70
No. I	+	....	290	....	....	+	+	....	+	....	....	....	....	....	+	+	76
No. V	+	....	277	....	....	+	+	....	....	....	....	....	+	....	....	....	78
No IX	+	....	269	....	....	+	+	....	+	+	....	+	....	+	....	....	75

in storage for twenty-four days, lot B for eleven days, and lot C for three days. The second scoring was made November 14th and the third not until June 3rd. The first and second scorings included the samples kept at —6° C. only, the third included these and the salted samples kept at +6° C. The unsalted samples kept at +6° C. were not scored at all, and by June 3rd, were in such condition that a score could not be given. Table No. I gives the scores with the remarks assigned to each sample at the time of scoring by Mr. Liverance, who is in charge of the dairy at the Michigan Agricultural College. The "oystery" flavor which the butter had acquired by November 14th is of a peculiar nature and is due to the absorption of the odor of scrambled eggs which were placed in the storage room a few days before. It was unfortunate that the eggs had been placed in the storage room with the butter at this time, but the manager had removed his butter from the storage and could not give an entire room to our six tubs.

At the time of the last scoring, the butter was not in good condition, and only a relative, somewhat indefinite value could be given as a score for the different samples. The relative values assigned at the last scoring are in the same ratio as the preceding scores. And those of the salted samples, Nos. I, V and IX, which were kept at +6° C. are higher than those of the unsalted samples, Nos. IV, VIII and XII, kept at —6° C.; the salted at —6° C. has the highest score.

Though the absolute scores are perhaps not quite proper, the relative scores show, doubtless, that there is no hope of keeping unsalted butter for a longer time than salted butter. This experience disagrees with the statement of Lowe, that "while in cold store, unsalted butter will keep as long as salted." It agrees with the experience of butter experts, who claim that mild salted butter keeps longer than either unsalted or high salted butter. The reason why the unsalted butter did not keep is probably because the moisture did not freeze. It is a phenomenon well known to the physicist that water, if kept quietly in clean, smooth walled containers, may be cooled to several degrees below the freezing point without becoming solid, but it solidifies the moment it is touched or shaken. In pushing the trier in the unsalted butter for sampling we could feel and hear the breaking ice crystals probably created by touching the undercooled drops with the trier. But the butter was yielding, not rigid. Now, if the moisture in the butter is not frozen, of course the deterioration will take place faster in the unsalted samples no matter whether the change is due to bacteria, enzymes or purely chemical reactions.

The just mentioned experience of butter experts and dealers that mild salted butter keeps better than either unsalted or high salted butter, has been proven by the experiments of the German Public Health Department in 1905 (Kraus) and also by the United States Department of Agriculture, 1906 (Gray). Fettick has lately tried to explain this by the selective influence of salt upon the flora of the butter. This probability had been discussed before in a more general way by Pettersson. Fettick thinks that the salt in a certain concentration will still allow the lactics to develop slowly and keep other bacteria in check, while objectionable molds, especially Oidium, are suppressed. If, however, the salt concentration is so high as to stop the activity of the lactics,

some more resistant organisms will have a chance to grow and to decompose the butter. The experiments of Fettick with pure cultures are in several cases contradictory to the statements of other authors, e. g., he notices a good development of B. coli in butter with 6% salt, corresponding to a saturated brine, while according to Pettersson and Stadler an 8% brine is the limit. Fettick states a good growth of B. prodigiosus in butter with 4% salt or a 28% brine, while Matzuschita could see no growth in a 10.5% salt agar. But from analogies in other salted food preserves, we cannot help believing this theory. It is, as far as we can see, the only probable explanation of the best keeping of light salted butter.

THE CHEMICAL METHODS EMPLOYED IN DETERMINING THE CHANGES.

Obtaining Samples.—As it was not always convenient or desirable to collect samples for the chemical and the bacteriological analyses at the same time, and as a portion of the butter can be used for chemical analysis that would be objectionable for bacteriological, the samples were collected separately.

All chemical analyses in this paper were run in duplicates. For the chemical analyses a sample of butter (about 600 grs.), not including surface butter, was taken from the tub with a knife or heavy spoon and placed in a one-quart Mason jar. The jar was set in warm water at about 40° C. until the butter was melted, or nearly so, then the sample was stirred with a glass rod to make it homogeneous. If the sample was too thin, it was cooled by placing the jar in cold water until the butter would just flow.

Moisture.—The moisture was determined by the official method.

Acidity—Exactly 5 grams (to the .05 part of a gram) of butter were introduced into a weighed 60 cc. Erlenmeyer flask on an open balance by means of a pipette. The flask containing the sample was warmed above the melting point of butter, then 0.5 cc. of phenolphthalein (1% in alcohol) and 25 cc. of a neutral mixture of equal parts of alcohol and ether were added. $^{N}/_{10}$ potassium hydroxid was added gradually from a burette until a pink color was produced, which would not disappear upon shaking for a few seconds. The acidity was recorded in terms of cc. of $^{N}/_{1}$ acid per 100 grams of butter (degrees of rancidity).

Total Nitrogen.—About 5 grams of butter were introduced into a weighed 500 cc. Kjeldahl flask by means of a pipette so that no butter came in contact with the neck of the flask, and weighed accurately to the tenth of a gram. About 60 cc. of sulphuric acid and about 0.5 gram of copper sulphate were added to the flask and the digestion conducted as in the Kjeldahl process. The distillation was made according to the official methods by making the mixture alkaline with sodium hydroxid and distilling into standard acid. The results were recorded as percentage of nitrogen in butter.

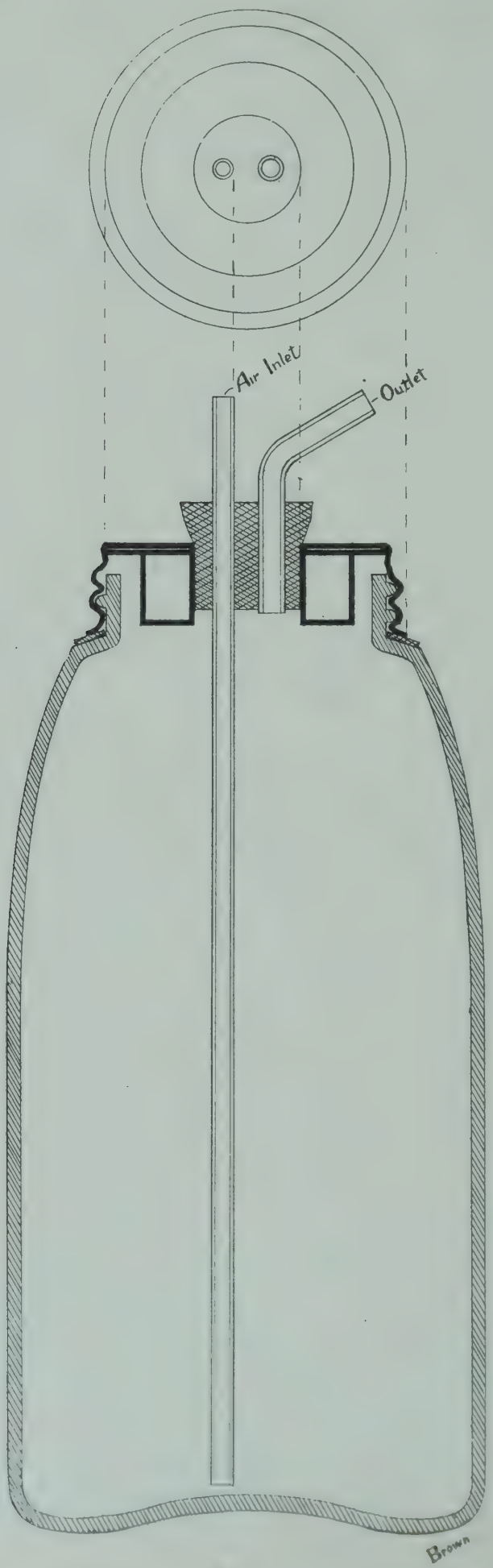


FIG. I.

Ammonia.—About 50 grams of butter were introduced into a weighed 500 cc. Kjeldahl flash by means of a pipette and weighed. Then 200 cc. of water and about 25 grams of magnesium oxid were added. The flask was connected with the condenser and about 100 cc. of the liquid distilled into standard acid. The neutralizing power of the distillate was recorded in percentage as nitrogen in the form of ammonia.

Washing the Butter.—As it is most convenient in determining salt, sugar, soluble acids and soluble proteins to wash the butter and use the washings, we washed the samples as follows:

Into a weighed two-quart Mason jar about 500 grams of butter were poured and weighed to the 0.5 of a gram. Then two grams of hot water (70° C. to 75° C.) for every gram of butter was poured into the jar and the water and butter stirred occasionally for about an hour. The cover (See Fig. 1) to which an arrangement for letting in air and drawing off water had been attached was put on and the jar inverted. After fifteen or twenty minutes, the water which had separated from the fat was drawn off. Aliquot parts were taken for analyses.

Now, as the samples of butter contain water as moisture and as the moisture in each gram of the sample is mixed with the two grams of wash water, the moisture must be considered. The soluble substances in each gram of butter are contained in the moisture (about 0.15 gram) plus the two grams of wash water (making about 2.15 cc. of washings represent 1 gram of butter).

Acidity of Washings.—The acid in 50 cc. of the washings was determined by titrating with standard potassium hydroxid, using phenolphthalein as indicator. The acidity was expressed in terms of cc. of $^{N}/_{10}$ per 100 grams of butter.

Salt.—The percentage of salt was determined by taking 5 cc. of the washings and titrating with a standard solution of silver nitrate. The results were recorded as percentage of salt in butter.

Nitrogen in Washings not Precipitated by Copper Sulphate.—Richmond and Boseley's modification of Ritthausen's method for the determination of the total protein in milk was used to precipitate the protein from the washings. Two hundred cubic centimeters of washings were introduced into a graduated 250 cc. flask, and enough normal sodium hydroxid to make the washings 5° alkaline (Fuller's scale) was added. A 10% solution of copper sulphate was added until precipitation was complete, then the flask was filled to the 250 cc. mark with water. After standing an hour the liquid was filtered. One hundred cubic centimeters of the filtrate were introduced into a Kjeldahl flask by means of a pipette and the nitrogen determined by adding 10 cc. of sulphuric acid, evaporating down, digesting and distilling. The results were recorded as percentage of butter.

Nitrogen in Washings not Precipitated by Tannic Acid and Sodium Chlorid.—The method set forth by Van Slyke and Hart for the determination of nitrogen in the form of peptones was used to throw down the proteins in the washings. Into a graduated 250 cc. flask were poured 200 cc. of the washings; just enough normal sodium hydroxid was added to make it neutral. About 1 gram of sodium chlorid was added to the sample of washings from the unsalted butter (none was added to the washings from the salted) and a solution containing 15%

of tannin was added gradually until precipitation was complete. The contents of the flask were made up to the 250 cc. mark with water, and, after standing an hour, were filtered. The nitrogen in 100 cc. of the filtrate was determined and recorded as percentage of butter.

Nitrogen in Washings not Precipitated by Phosphotungstic Acid with Sulphuric Acid.—The method employed here is described by Van Slyke and Hart. Two hundred cubic centimeters of the washings were poured into a graduated flask, 5 cc. of strong sulphuric acid added, then a solution of 30% phosphotungstic acid until one drop gave no further precipitation in the clear supernatant liquid. It was diluted to the 250 cc. mark, and, after standing half an hour, was filtered. The nitrogen in 100 cc. of the filtrate was determined and recorded as percentage of butter.

Nitrogen in Washings not Precipitated by Acetic Acid.—The official method for the determination of casein in milk was used to precipitate the casein and any paranuclein that was present in the washings. Into a sugar flask graduated at 100 cc. and 110 cc. were run 100 cc. of the washings and warmed to about 40° c., then 10 cc. of $^{N}/_{1}$ acetic acid were added. The liquid was shaken, allowed to stand for a few minutes and filtered, and the filtrate passed through the same filter a second time. The nitrogen in 25 cc. of the filtrate was determined and recorded as percentage of butter.

Lactose.—The official gravimetric method was followed. After the proteins were removed from the washings with copper sulphate in the manner described above, the lactose was determined in aliquot parts of the filtrate by boiling for six minutes with Allihn's modification of Fehling's solution. The cuprous oxid was weighed direct and the lactose corresponding to the reduced copper was recorded as percentage of butter.

GENERAL TABLES GIVING THE RESULTS OF CHEMICAL DETERMINATIONS.

The following table gives all data of the chemical analyses which will be discussed in the following pages.

TABLE II.

Sample No. I.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Acetic acid.	
6 hours	2.1°	13.26%	1.69%	.....	2.1°	.0734%	.0042%	.0043%	.0037%	.....	.0016%
6 hours	2.1°	13.23%	1.69%	.....	2.1°	.0739%	.0042%	.0042%	.0037%	.....	.0017%
2 days	2.4°	.....	.....	.....	2.1°	.....	.0040%	.0052%	.0034%	.....	.....
2 days	2.4°	.....	.....	.....	2.1°	.....	.0043%	.0052%	.0035%	.....	.....
28 days	2.8°	.....	.....	.....	3.0°	.....	.0045%	.0054%	.0045%	.....	.....
28 days	2.8°	.....	.....	.....	3.2°	.....	.0045%	.0056%	.0045%	.....	.....
56 days	3.8°	.....	.....	.....	3.0°	.....	.0050%	.0074%	.0046%	.....	.....
56 days	3.9°	.....	.....	.....	3.2°	.....	.0052%	.0074%	.0048%	.....	.....
104 days	4.5°	10.49%	.....	.....	4.2°	.0756%	.0061%	.0059%	.0056%	.....	.0015%
104 days	4.5°	10.78%	.....	.....	4.2°	.0784%	.0063%	.0059%	.0056%	.....	lost
219 days	6.4°	9.97%	1.32%	.16%	4.2°	.0785%	.0085%	.0063%	.0068%	.0149%	.....
219 days	6.5°	9.90%	1.32%	.18%	4.2°	.0812%	.0083%	.0063%	.0066%	.0151%	.....

Sample No. II.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic Acid.	Phosphotungstic acid.	Acetic acid.	
6 hours	2.8°	12.96%	0	.....	3.2°	lost	.0041%	.0052%	.0037%	.....	.0014%
6 hours	2.8°	12.99%	0	.....	3.2°	lost	.0041%	.0052%	.0035%	.....	.0014%
2 days	2.8°	.....	.....	.....	4.3°	.0728%	.0042%	.0047%	.0035%	.....	.....
2 days	2.9°	.....	.....	.....	4.3°	.0672%	lost	.0050%	.0034%	.....	.....
28 days	4.2°	.....	.....	.....	5.3°	.....	.0084%	.0100%	.0052%	.....	.....
28 days	4.2°	.....	.....	.....	5.3°	.....	.0084%	.0100%	.0054%	.....	.....
56 days	5.6°	.....	.....	.....	6.0°	.....	.0094%	.0112%	.0065%	.....	.....
56 days	5.6°	.....	.....	.....	6.0°	.....	.0097%	.0115%	.0065%	.....	.....
104 days	8.7°	12.26%	.....	.....	7.7°	.0728%	.0119%	.0099%	.0080%	.....	.0014%
104 days	8.8°	12.38%	.....	.....	7.7°	.0756%	.0122%	.0099%	.0082%	.....	.0014%
219 days	12.4°	13.24%	0	.17%	8.1°	.0785%	.0194%	.0131%	.0159%	.0205%	.....
219 days	12.6°	13.15%	0	.18%	8.5°	.0756%	.0194%	.0134%	.0161%	.0211%	.....

TABLE II.—Continued.

Sample No. III.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Acetic acid.	
6 hours	2.1°	13.26%	1.69%	.....	2.1°	.0734%	.0042%	.0042%	.0037%	.....	.0016%
6 hours	2.1°	13.23%	1.69%	.....	2.1°	.0739%	.0042%	.0043%	.0037%	.....	.0017%
41 days	2.5°	.....	.....	.....	3.4°	.....	.0045%	.0056%	.0042%	.....	.....
41 days	2.6°	.....	.....	.....	3.4°	.....	.0045%	.0058%	.0043%	.....	.....
57 days	2.6°	.....	.....	.....	3.6°	.....	.0050%	.0058%	.0037%	.....	.....
57 days	2.7°	.....	.....	.....	3.8°	.....	.0050%	.0058%	.0039%	.....	.....
185 days	3.0°	.....	1.20%	.....	4.7°	.....	.0056%	.0047%	.0041%	.....	.....
185 days	3.0°	.....	1.23%	.....	4.7°	.....	.0062%	.0049%	.0041%	.....	.....
253 days	3.0°	10.90%	1.25%	.30%	3.2°	.0686%	.0067%	.0057%	.0047%	.0196%	.0015%
253 days	3.2°	11.03%	1.27%	.29%	3.4°	.0728%	.0071%	.0059%	.0049%	.0202%	.0018%

Sample No. IV.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic Acid.	Phosphotungstic acid.	Acetic acid.	
6 hours	2.8°	12.96%	0	.....	3.2°	.0728%	.0041%	.0051%	.0037%	.....	.0014%
6 hours	2.8°	12.99%	0	.....	3.2°	.0672%	.0041%	.0052%	.0035%	.....	.0014%
41 days	3.3°	.....	.....	.....	5.1°	.....	.0057%	.0069%	.0060%	.....	.....
41 days	3.3°	.....	.....	.....	5.1°	.....	.0060%	.0069%	.0060%	.....	.....
57 days	3.6°	.....	.....	.....	6.4°	.....	.0067%	.0079%	.0050%	.....	.....
57 days	3.8°	.....	.....	.....	6.4°	.....	.0069%	.0079%	lost	.....	.....
185 days	3.6°	.....	.....	.....	6.7°	.....	.0067%	.0052%	.0052%	.....	.....
185 days	3.7°	.....	.....	.....	7.2°	.....	.0071%	.0057%	.0052%	.....	.....
253 days	3.6°	13.26%	0	.24%	4.7°	.0728%	.0069%	.0064%	.0062%	.0223%	.0013%
253 days	3.6°	13.32%	0	.19%	4.6°	.0700%	.0069%	.0067%	.0060%	.0229%	.0017%

TABLE II.—Continued.

Sample No. V.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Acetic acid.	
8 hours	1.9°	13.75%	2.65%	.....	3.2°	.0726%	.0034%	.0042%	.0034%	.....	.0013%
8 hours	2.0°	13.65%	2.69%	.....	3.2°	.0774%	.0034%	.0042%	.0034%	.....	.0015%
10 days	2.0°	.....	.....	.....	3.2°	.....	.0034%	.0037%	.0034%	.....	.....
10 days	2.0°	.....	.....	.....	3.2°	.....	.0034%	.0037%	.0034%	.....	.....
22 days	2.2°	.....	.....	.....	3.2°	.....	.0032%	.0042%	.0042%	.....	.....
22 days	2.4°	.....	.....	.....	3.4°	.....	.0034%	.0045%	.0043%	.....	.....
52 days	2.6°	.....	.....	.....	3.6°	.....	.0045%	.0050%	.0042%	.....	.....
52 days	2.6°	.....	.....	.....	3.8°	.....	0045%	.0050%	.0045%	.....	.....
91 days	2.0°	11.30%	.....	.....	5.3°	.0742%	.0041%	.0044%	.0039%	.....	.0020%
91 days	2.1°	11.36%	.....	.....	5.5°	.0756%	.0041%	.0044%	.0039%	.....	lost
225 days	2.7°	10.87%	2.56%	.24%	3.9°	.0756%	.0050%	.0046%	.0049%	.0111%	.....
225 days	2.8°	10.92%	2.60%	.26%	4.0°	.0728%	.0050%	.0049%	.0050%	.0117%	.....

Sample No. VI.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic Acid.	Phosphotungstic acid.	Acetic acid.	
8 hours	2.4°	17.10%	0	.....	5.4°	.0781%	.0040%	.0050%	.0040%	.....	.0015%
8 hours	2.5°	17.91%	0	.....	5.4°	.0830%	.0042%	.0050%	.0042%	.....	.0016%
10 days	2.6°	.....	.....	.....	5.9°	.....	.0035%	.0040%	.0036%	.....	.....
10 days	2.6°	.....	.....	.....	6.1°	.....	.0035%	.0040%	.0036%	.....	.....
22 days	2.8°	.....	.....	.....	6.5°	.....	.0051%	.0065%	.0061%	.....	.....
22 days	3.0°	.....	.....	.....	6.5°	.....	.0053%	.0066%	.0061%	.....	.....
52 days	5.6°	.....	.....	.....	6.5°	.....	.0091%	.0108%	.0070%	.....	.....
52 days	5.6°	.....	.....	.....	6.5°	.....	.0095%	.0108%	.0072%	.....	.....
91 days	12.8°	15.34%	.....	.....	9.0°	.0812%	.0159%	.0163%	.0111%	.....	.0022%
91 days	13.0°	15.44%	.....	.....	9.0°	.0840%	.0163%	.0163%	.0111%	.....	.0022%
225 days	19.8°	14.21%	0	.21%	18.7°	.0850%	.0344%	.0289%	.0281%	.0435%	.....
225 days	20.0°	13.97%	0	.27%	19.3°	.0858%	.0337%	.0300%	.0289%	.0435%	.....

TABLE II.—Continued.

Sample No. VII.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Acetic acid.	
8 hours	1.9°	13.75%	2.65%	.....	3.2°	.0726%	.0034%	.0042%	.0034%	.....	.0013%
8 hours	2.0°	13.65%	2.69%	.....	3.2°	.0747%	.0034%	.0042%	.0034%	.....	.0015%
25 days	1.8°	.....	.....	.....	3.4°	.....	.0032%	.0043%	.0034%	.....	.....
25 days	2.0°	.....	.....	.....	3.4°	.....	.0032%	.0047%	.0035%	.....	.....
59 days	2.0°	.....	.....	.....	4.3°	.....	.0037%	.0045%	.0037%	.....	.....
59 days	2.0°	.....	.....	.....	4.7°	.....	.0037%	.0045%	.0037%	.....	.....
184 days	2.1°	.....	2.07%	.....	4.7°	.....	.0043%	.0049%	.0042%	.....	.....
184 days	2.1°	.....	2.08%	.....	4.9°	.....	.0045%	.0049%	.0042%	.....	.....
240 days	1.9°	11.47%	2.09%	.17%	3.4°	.0784%	.0045%	.0047%	.0037%	.0097%	.0014%
240 days	2.0°	11.52%	2.32%	.18%	3.7°	.0812%	.0045%	.0049%	.0037%	.0103%	.0017%

Sample No. VIII.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic Acid.	Phosphotungstic acid.	Acetic acid.	
8 hours	2.4°	17.10%	0	.....	5.4°	.0781%	.0040%	.0050%	.0040%	.....	.0015%
8 hours	2.5°	17.91%	0	.....	5.4°	.0830%	.0042%	.0050%	.0042%	.....	.0016%
25 days	2.6°	.....	.....	.....	5.4°	.....	.0042%	.0053%	.0042%	.....	.....
25 days	2.6°	.....	.....	.....	5.6°	.....	.0042%	.0055%	.0043%	.....	.....
59 days	2.8°	.....	.....	.....	6.9°	.....	.0055%	.0055%	.0053%	.....	.....
59 days	2.8°	.....	.....	.....	6.9°	.....	.0055%	.0057%	.0053%	.....	.....
184 days	2.6°	.....	.....	.....	5.6°	.....	.0055%	.0057%	.0051%	.....	.....
184 days	2.8°	.....	.....	.....	5.6°	.....	.0057%	.0057%	.0053%	.....	.....
240 days	2.3°	14.90%	0	.24%	5.9°	.0868%	.0060%	.0054%	.0054%	.0173%	.0015%
240 days	2.4°	15.17%	0	.27%	6.4°	.0840%	.0060%	.0055%	.0055%	.0185%	.0019%

TABLE II.—Continued.

Sample No. IX.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Acetic acid.	
7 hours	2.0°	15.52%	5.05%	.....	2.2°	.0617%	.0047%	.0049%	.0034%	.....	.0012%
7 hours	2.0°	15.64%	5.11%	.....	2.2°	.0635%	.0049%	.0053%	.0038%	.....	.0012%
9 days	2.9°	.....	.....	.....	2.2°	.....	.0064%	.0051%	.0038%	.....	.....
9 days	2.9°	.....	.....	.....	2.2°	.....	.0062%	.0053%	.0040%	.....	.....
27 days	4.0°	.....	.....	.....	2.2°	.....	.0051%	.0075%	.0038%	.....	.....
27 days	4.2°	.....	.....	.....	2.2°	.....	.0051%	.0077%	.0038%	.....	.....
44 days	5.0°	.....	.....	.....	3.6°	.....	.0083%	.0081%	.0038%	.....	.....
44 days	5.2°	.....	.....	.....	3.6°	.....	.0085%	.0081%	.0038%	.....	.....
154 days	6.6°	11.90%	.....	.....	3.6°	.0644%	.0076%	.0074%	.0045%	.....	.0015%
154 days	6.8°	11.72%	.....	.....	3.8°	.0672%	.0074%	.0072%	.0046%	.....	.0016%
217 days	7.8°	10.47%	3.18%	.20%	2.6°	.0616%	.0066%	.0056%	.0050%	.0141%	.....
217 days	7.8°	10.88%	3.19%	.24%	2.6°	.0700%	.0068%	.0059%	.0050%	.0155%	.....

Sample No. X.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic Acid.	Phosphotungstic acid.	Acetic acid.	
7 hours	2.3°	15.60%	0	.....	4.3°	.0699%	.0045%	.0057%	.0042%	.....	.0012%
7 hours	2.3°	16.08%	0	.....	4.3°	.0704%	.0049%	.0057%	.0045%	.....	.0012%
9 days	4.5°	.....	.....	.....	4.3°	.....	.0051%	.0066%	.0057%	.....	.....
9 days	4.6°	.....	.....	.....	4.3°	.....	.0051%	.0066%	.0057%	.....	.....
27 days	7.4°	.....	.....	.....	5.4°	.....	.0075%	.0095%	.0062%	.....	.....
27 days	7.5°	.....	.....	.....	5.4°	.....	.0080%	.0093%	.0060%	.....	.....
44 days	10.4°	.....	.....	.....	6.5°	.....	.0102%	.0095%	.0053%	.....	.....
44 days	10.3°	.....	.....	.....	6.5°	.....	.0102%	.0095%	.0057%	.....	.....
154 days	12.5°	14.13%	.....	.....	7.9°	.0700%	.0147%	.0117%	.0093%	.....	.0015%
154 days	12.9°	14.29%	.....	.....	8.1°	.0756%	.0151%	.0121%	.0095%	.....	.0017%
217 days	27.0°	13.98%	0	.18 %	9.1°	.0756%	.0181%	.0143%	.0117%	.0186%	.....
217 days	27.2°	14.11%	0	.19 %	9.1°	.0728%	.0185%	.0145%	.0121%	.0199%	.....

TABLE II.—Concluded.

Sample No. XI.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Acetic acid.	
7 hours	2.0°	15.52%	5.05%	.....	2.2°	.0617%	.0047%	.0089%	.0034%	.....	.0012%
7 hours	2.0°	15.64%	5.11%	.....	2.2°	.0635%	.0049%	.0053%	.0038%	.....	.0012%
24 days	2.7°	.....	.....	.....	2.1°	.....	.0057%	.0064%	.0038%	.....	.....
24 days	2.7°	.....	.....	.....	2.1°	.....	.0058%	.0068%	.0042%	.....	.....
57 days	3.2°	.....	.....	.....	3.2°	.....	.0050%	.0057%	.0038%	.....	.....
57 days	3.2°	.....	.....	.....	3.2°	.....	.0050%	.0057%	.0040%	.....	.....
183 days	4.6°	.....	3.04%	.....	4.9°	.....	.0059%	.0062%	.0041%	.....	.....
183 days	4.6°	.....	3.05%	.....	4.9°	.....	.0059%	.0064%	.0041%	.....	.....
232 days	4.9°	11.80%	3.34%	.20%	4.2°	.0644%	.0074%	.0050%	.0054%	.0228%	.0013%
232 days	4.9°	11.94%	3.29%	.21%	4.4°	.0658%	.0076%	.0052%	.0056%	.0242%	.0015%

Sample No. XII.

Age of butter.	Total acidity.	Moisture.	Salt.	Lactose.	Acidity of washings.	Total nitrogen.	Nitrogen in washings not precipitated by				Nitrogen in form of ammonia.
							Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Acetic acid.	
7 hours	2.3°	15.60%	0	.....	4.3°	.0699%	.0045%	.0057%	.0042%	.....	.0012%
7 hours	2.3°	16.08%	0	.....	4.3°	.0704%	.0049%	.0057%	.0045%	.....	.0012%
24 days	3.6°	.....	.....	.....	3.0°	.....	.0047%	.0058%	.0040%	.....	.....
24 days	3.7°	.....	.....	.....	3.0°	.....	.0050%	.0060%	.0042%	.....	.....
57 days	4.4°	.....	.....	.....	4.5°	.....	.0060%	.0060%	.0042%	.....	.....
57 days	4.5°	.....	.....	.....	4.7°	.....	.0060%	.0065%	.0045%	.....	.....
183 days	5.9°	.....	.....	.....	7.1°	.....	.0083%	.0065%	.0045%	.....	.....
183 days	6.1°	.....	.....	.....	7.3°	.....	.0085%	lost.	.0047%	.....	.....
232 days	7.1°	14.99%	0	.23%	6.5°	.0700%	.0075%	.0060%	.0047%	.0185%	.0012%
232 days	7.2°	15.11%	0	.23%	6.7°	.0714%	.0080%	.0065%	.0050%	.0185%	.0016%

THE RELATION OF THE SALT AND MOISTURE CONTENT TO THE ALTERATIONS OCCURRING.

In all samples the percentages of salt and moisture decrease and, after about eight months of storage, there is a considerable difference between the fresh and the old samples. The loss of moisture is on the average:

of the three salted warm samples.....	3.67%
of the unsalted warm samples.....	1.66%
of the salted cold samples.....	2.73%
of the unsalted cold samples.....	0.99%

The salted samples lose more moisture than the unsalted ones, which is usually explained by the precipitation of the proteins in butter, causing a lower viscosity of the buttermilk and a more open texture.

The loss of moisture is not caused by evaporation, but by leakage, as can be determined easily by the salt concentration; if the water had evaporated, there would be an increase in the percentage of salt; if the water disappeared by leakage or absorption by the tubs, the salt and water would disappear in the same proportion and the concentration of the brine would be the same. The following table shows the concentration of brine in the salted samples, and also the theoretical concentration computed under the supposition that the water had evaporated:

TABLE III,

Brine Concentration in Fresh and Old Butter.

Stored at +6° C.				Stored at —6° C.			
No.	Fresh.	Old.	Computed.	No.	Fresh.	Old.	Computed.
I.....	12.8%	13.3%	17.0%	III.....	12.8%	11.5%	15.4%
V.....	19.5%	23.6%	24.5%	VII.....	19.5%	19.2%	23.2%
IX.....	32.6%	29.8%	47.6%	XI.....	32.6%	28.0%	42.8%
Average.....	21.6%	22.6%	29.7%	Average.....	21.6%	19.6%	27.2%

The brine concentration is nearly constant, proving the loss of moisture to be due almost entirely to leakage.

We must conclude from this circumstance that, in comparing water soluble compounds of butter, we get more accurate results by recording them not in percentages of butter but in percentages of the moisture. We shall make use of this method of interpretation in the discussion of the soluble nitrogen. This is allowed, however, for soluble substances only. The insoluble compounds will increase in the same ratio the water decreased, e. g., the total nitrogen, the larger part of which is insoluble, shows a slight increase in the old butter. (See page 471.)

DECOMPOSITION IN THE LIGHT OF ACIDITY.

It has been believed that the acidity of butter is a measure of rancidity and that butter in becoming rancid increases in acidity. Butter is said to be rancid if it has an undesirable taste or smell, due to an aged condition, that cannot be described definitely by other terms. Two butters may be scored "rancid" and not have the same defect in odor or taste. The rancidity, the aged condition, or the acquired unpleasant undesirable odor or taste is not dependent on an increase in acidity; the work done in this laboratory last year supports this statement. It is true, however, that many butters with high acidity are scored "rancid;" and it is true, also, that butter in which there has been little or no increase in acidity may be said to be rancid by the butter judge.

All samples without salt stored at +6°C. showed a very high increase in acidity. These butters are excluded from the averages. Comparing the butter from the three creameries, the best butter, lot B, shows hardly any increase. Samples VII and VIII have no increase at all, and sample V, kept at +6°C. increased only from 2.0° to 2.8°. Butter from Creamery A was considerably higher in acidity and lot C was highest of all, scoring lowest and coming from the poorest creamery.

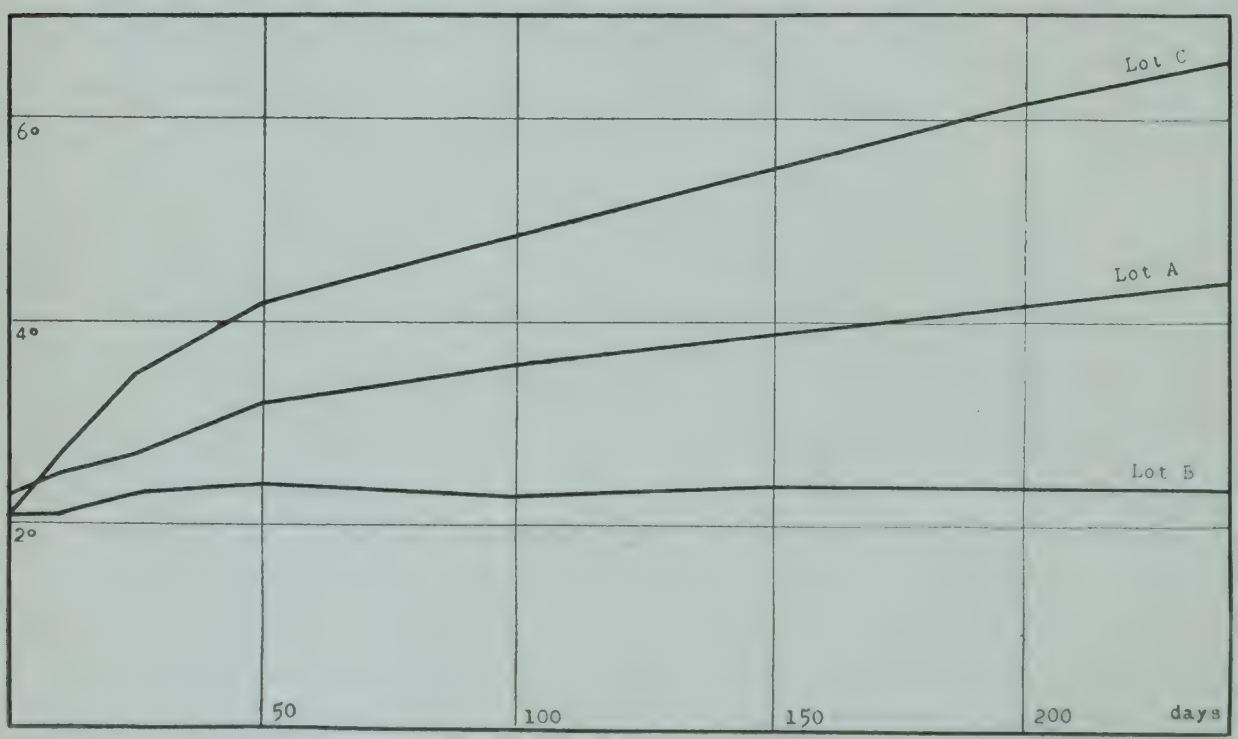


FIG. 2.—Average acidity of lots A, B and C (unsalted samples at + 6° C. not included).

Now, as these samples were placed in the same storage and had practically the same initial acidity, the cause of a greater increase in one lot than in another has its origin back of the storage and could be said to be due to the handling of the cream, to the methods of manufacture or to micro-organisms and their enzymes. In looking over the methods of manufacture, we notice that the cream from which lot B was made

was whole milk cream ripened at the creamery, that the cream for lot A was a mixture of gathered and whole milk cream ripened for forty-eight hours at a low temperature and that the cream for lot C was gathered cream ripened naturally. It is plain to be seen that the difference in handling could account for the different rate of increase in acidity; and, too, that the different methods of ripening would favor the development of different micro-organisms which might cause in the finished butter a rapid or retarded increase in acidity. In Fig. 3, the curves show that the average increase in acidity of three samples, one

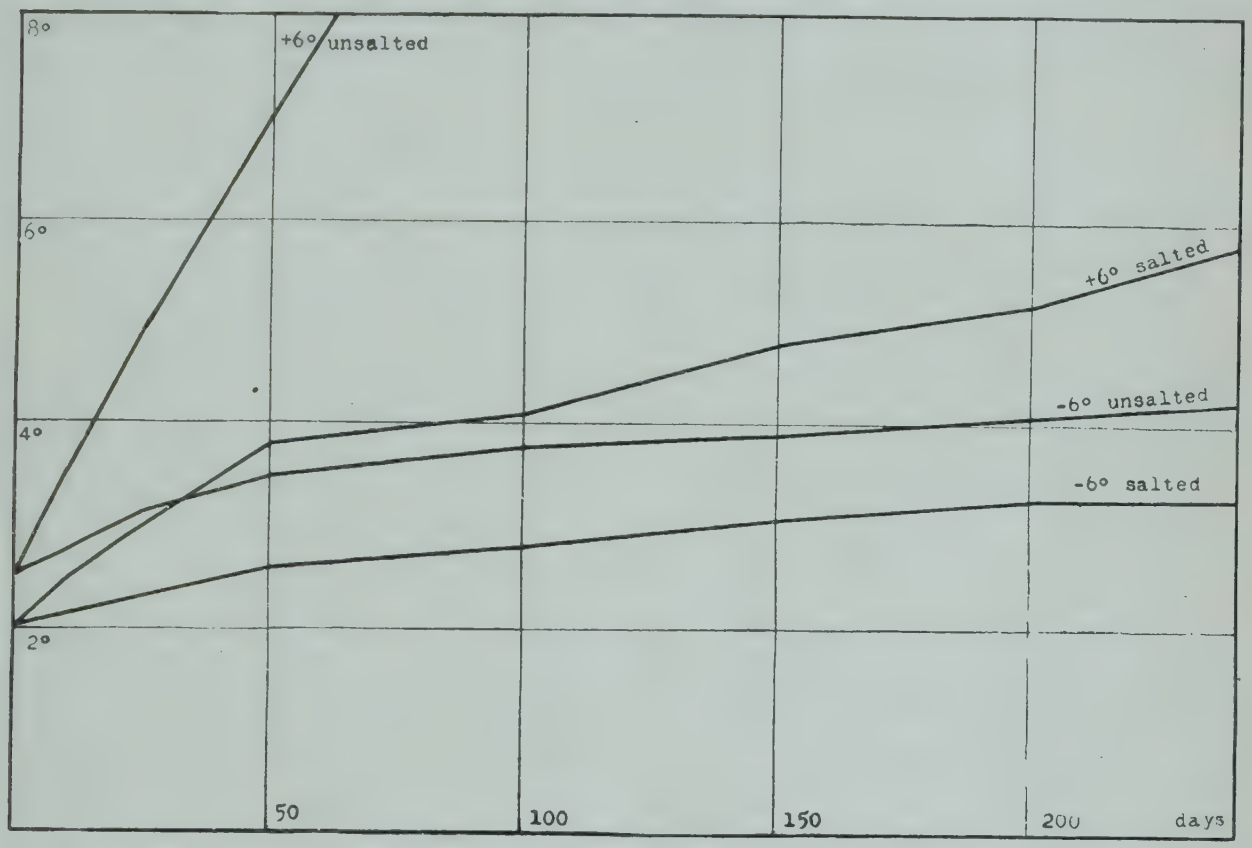


FIG. 3.—Effect of salt and temperature upon the acidity. Average of three different butters.

from each of three different lots, is small in the unsalted butter at —6° C., less in the salted at —6° C., more in the salted at +6° C., and beyond bounds in the unsalted at +6° C. The comparative scores of the salted samples at +6° C. are higher than those of the unsalted at —6° C., notwithstanding that they have a greater increase in acidity. Inasmuch as two out of the six samples stored at —6° C. remained for eight months without an increase in acidity and as they deteriorated from 93 and 90 to 82 and 79 respectively, an increase of acidity is not necessarily coincident with the spoiling of butter.

Soluble Acids—The acidity of the washings of butter determined in the manner described under methods is regarded as representing soluble acids. These acids constitute about one-tenth of the total acidity, run almost parallel with it and increase where it increases.

THE SIGNIFICANCE OF LACTOSE EXERTING SOME INFLUENCE ON THE KEEPING QUALITIES.

We determined the lactose in the samples at the end of the experiment and not while they were fresh; our conclusions are, therefore, quite limited. The amount of lactose found in the butters varied from 0.17 to 0.30%. Fresh butter has about 0.35 to 0.39% lactose, according to Storch. We were surprised not to see more lactose decomposed in the samples kept above the freezing point. If we record the data in the more correct way by computing them in percentage of the moisture in butter, we get the following table:

TABLE IV.

Lactose as Percentage of Moisture in Butter.

	Stored at +6° C.		Stored at —6° C.	
	Salted.	Unsalted.	Salted.	Unsalted.
Lot A	1.7%	1.4%	2.7%	1.7%
Lot B	2.3%	1.7%	1.6%	1.7%
Lot C	2.1%	1.4%	1.8%	1.5%
Average	2.0%	1.5%	2.0%	1.6%

The data of Storch's mentioned above give a concentration of 2.3 to 2.9% lactose, the rest having been used up in the ripening process or lost by the washing. From this it seems there is very little decomposition in the salted, and more in the unsalted samples. There seems to be little or no relation between the water soluble acids and the amount of lactose gone, since most of the water soluble acids are cleavage products of fat, as butyric, capronic, etc., acids. So much lactose, especially in the unsalted warm samples which had an abundant growth of Oidium and Penicillium, was not expected. There is, of course, a possibility that reducing substances have been formed during the storing and that our results do not give the correct amount of lactose.

THE ROLE OF PROTEID DEGRADATION.

The decomposition of proteins is one of the main points in this publication. The original data concerning the total and soluble nitrogen are given in Table II on page 16. Table V on the next page gives the "amid nitrogen" in percentage of the total nitrogen. The word "amid nitrogen" is not strictly correct (see page 477), but is used by a number of authors especially in the cheese ripening to name this group of compounds briefly in one word.

We are interested in the "amid compounds" since among these we

find at times a strong pronounced flavor and odor, while the peptones, peptids and similar water-soluble substances have little, if any, taste or odor.

The percentage of total nitrogen increased a little due to the loss of water (see page 467) that carried away the soluble substances, the nitrogenous material being in large part insoluble. Therefore, we find, in the average of all samples, the total nitrogen in fresh butter to be 0.0720%, after 100 days 0.0745%, and after 250 days 0.0750% of the weight of butter.

TABLE V.

AMID NITROGEN IN PERCENTAGE OF TOTAL NITROGEN.

Age of butter.	*Sample No. I.* Total nitrogen.	% of total nitrogen not precipitated by: Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %	*Sample No. II.* Total nitrogen.	% of total nitrogen not precipitated by: Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %
6 hours	.0734	5.58	5.58	4.90	5.37	lost	5.60	7.11	5.06	5.88
6 hours	.0739	5.58	5.70	4.90	.....	lost	5.60	7.11	4.78	.....
2 days	.....	5.30	6.92	4.52	5.67	.0728	5.74	6.42	4.64	5.69
2 days	.....	5.70	6.92	4.65	.....	.0672	lost	6.84	4.78	.....
28 days	.....	5.98	7.18	5.98	6.42	.....	11.57	13.67	7.11	10.83
28 days	.....	5.98	7.43	5.98	.....	.....	11.57	13.67	7.38	.....
56 days	.....	6.64	9.85	6.10	7.62	.....	12.83	15.30	8.88	12.48
56 days	.....	6.92	9.85	6.37	.....	.....	13.25	15.72	8.88	.....
104 days	.0756	8.10	7.84	7.43	7.83	.0728	16.25	13.53	10.93	13.71
104 days	.0784	8.37	7.84	7.43	.....	.0756	16.68	13.53	11.35	.....
219 days	.0785	11.05	8.37	8.77	9.48	.0785	26.50	17.95	21.75	22.16
219 days	.0812	11.30	8.37	9.00	.....	.0756	26.50	18.27	22.00	.....

Age of butter.	*Sample No. III.* Total nitrogen.	% of total nitrogen not precipitated by: Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %	*Sample No. IV.* Total nitrogen.	% of total nitrogen not precipitated by: Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %
6 hours	.0734	5.58	5.58	4.90	5.37	.0728	5.60	7.11	5.06	5.88
6 hours	.0739	5.58	5.70	4.90	.....	.0672	5.60	7.11	4.78	.....
41 days	.....	5.97	7.44	5.57	6.39	.....	7.78	9.44	8.20	8.54
41 days	.....	5.97	7.70	5.71	.....	.....	8.20	9.44	8.20	.....
57 days	.....	6.64	7.70	4.91	6.46	.....	9.15	10.80	6.84	8.98
57 days	.....	6.64	7.70	5.18	.....	.....	9.43	10.80	lost	.....
185 days	.....	7.43	6.23	5.44	6.55	.....	9.15	7.12	7.11	8.00
185 days	.....	8.23	6.50	5.44	.....	.....	9.70	7.80	7.11	.....
253 days	.0686	8.89	7.57	6.24	7.74	.0728	9.42	8.75	8.48	8.90
253 days	.0728	9.42	7.84	6.50	.....	.0700	9.42	9.15	8.20	.....

TABLE V.—Continued.

Age of butter.	*Sample No. V.*					*Sample No. VI.*				
	Total nitrogen.	% of total nitrogen not precipitated by				Total nitrogen.	% of total nitrogen not precipitated by			
		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %
8 hours	.0726	4.47	5.53	4.47	4.82	.0830	4.80	6.00	4.80	5.27
8 hours	.0774	4.47	5.53	4.47	.....	.0781	5.03	6.00	5.03	.....
10 days	.....	4.47	4.87	4.47	4.60	.....	4.20	4.80	4.32	4.44
10 days	.....	4.47	4.87	4.47	.....	.....	4.20	4.80	4.32	.....
22 days	.....	4.22	5.53	5.53	5.22	.....	6.11	7.79	7.32	7.13
22 days	.....	4.47	5.92	5.67	.....	.....	6.35.	7.91	7.32	.....
52 days	.....	5.93	6.59	5.54	6.09	.....	10.90	12.93	8.40	10.86
52 days	.....	5.93	6.59	5.93	.....	.....	11.38	12.93	8.63	.....
91 days	.0742	5.40	5.79	5.14	5.44	.0812	19.05	19.55	13.30	17.38
91 days	.0756	5.40	5.79	5.14	.....	.0840	19.55	19.55	13.30	.....
225 days	.0756	6.58	6.05	6.45	6.23	.0850	41.30	34.60	33.70	36.77
225 days	.0728	6.58	6.45	6.58	.....	.0858	40.40	36.00	34.60	.....

Age of butter.	*Sample No. VII.*					*Sample No. VIII.*				
	Total nitrogen.	% of total nitrogen not precipitated by				Total nitrogen.	% of total nitrogen not precipitated by			
		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %
8 hours	.0726	4.47	5.53	4.47	8.42	.0830	4.80	6.00	4.80	5.28
8 hours	.0774	4.47	5.53	4.47	.....	.0781	5.03	6.00	5.03	.....
25 days	.....	4.22	5.67	4.47	4.89	.....	5.03	6.35	5.03	5.53
25 days	.....	4.22	6.18	4.60	.....	.....	5.03	6.60	5.15	.....
59 days	.....	4.87	5.92	4.87	5.22	.....	6.60	6.60	6.35	6.57
59 days	.....	4.87	5.92	4.87	.....	.....	6.60	6.83	6.35	.....
184 days	.....	5.67	6.45	5.52	5.92	.....	6.60	6.83	6.10	6.59
184 days	.....	5.92	6.45	5.52	.....	.....	6.83	6.83	6.35	.....
240 days	.0812	5.92	6.18	4.87	5.70	.0868	7.20	6.48	6.48	6.76
240 days	.0784	5.92	6.45	4.87	.....	.0840	7.20	6.60	6.60	.....

TABLE V.—Concluded.

Age of butter.	*Sample No. IX.*					*Sample No. X.*				
	Total nitrogen.	% of total nitrogen not precipitated by				Total nitrogen.	% of total nitrogen not precipitated by			
		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %
7 hours	.0635	7.25	7.58	5.25	6.96	.0704	6.24	7.91	5.83	7.12
7 hours	.0617	7.58	8.20	5.88	.....	.0699	6.80	7.91	6.25	.....
9 days	.....	9.58	7.88	5.87	7.94	.....	7.08	9.16	7.91	8.05
9 days	.....	9.90	8.20	6.18	.....	.....	7.08	9.16	7.91	.....
27 days	.....	7.88	11.60	5.87	8.50	.....	10.42	13.20	8.34	10.77
27 days	.....	7.88	11.90	5.87	.....	.....	11.10	12.93	8.61	.....
44 days	.....	12.85	12.50	5.87	10.45	.....	14.18	13.20	7.35	11.67
44 days	.....	13.13	12.50	5.87	.....	.....	14.18	13.20	7.91	.....
154 days	.0644	11.75	11.43	6.95	9.97	.0700	20.45	16.25	12.92	16.75
154 days	.0672	11.43	11.14	7.10	.....	.0756	20.90	16.80	13.20	.....
217 days	...0700	10.20	8.65	7.73	8.97	.0756	25.10	19.90	16.25	20.64
217 days	.0616	10.50	9.12	7.73	.....	.0728	25.70	20.10	16.80	.....

Age of butter.	*Sample No. XI.*					*Sample No. XII.*				
	Total nitrogen.	% of total nitrogen not precipitated by				Total nitrogen.	% of total nitrogen not precipitated by			
		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %		Copper sulphate.	Tannic acid.	Phosphotungstic acid.	Average %
7 hours	.0635	7.25	7.58	5.25	6.96	.0704	6.24	7.91	5.83	7.12
7 hours	.0617	7.58	8.20	5.88	.....	.0699	6.80	7.91	6.25	.....
24 days	.....	8.80	9.90	5.88	8.42	.....	6.52	8.05	5.55	6.87
24 days	.....	8.95	10.50	6.50	.....	.....	6.94	8.32	5.83	.....
57 days	.....	7.73	8.80	5.88	7.52	.....	8.32	8.32	5.83	7.68
57 days	.....	7.73	8.80	6.18	.....	.....	8.32	9.02	6.25	.....
183 days	.....	9.12	9.60	6.33	8.40	.....	11.54	9.03	6.25	9.03
183 days	.....	9.12	9.90	6.33	.....	.....	11.80	lost	6.52	.....
232 days	.0644	11.45	7.73	8.35	9.33	.0700	10.42	8.33	6.53	8.73
232 days	.0658	11.77	8.04	8.65	.....	.0714	11.10	9.03	6.94	.....

We shall discuss first the influence of salt and temperature upon the "amid nitrogen," averaging up all the results obtained with copper sulphate, tannic acid and phosphotungstic acid. The averages of three samples treated in the same way give the curves shown in Figure 4. The salted cold samples show a comparatively slight increase, the unsalted cold and the salted warm samples run almost parallel, while the unsalted warm samples have such a rapid increase that the curve passes the limit of our figure in 30 days. The increase of amid nitrogen in those samples is so high (20 to 36% of the total nitrogen) that we did

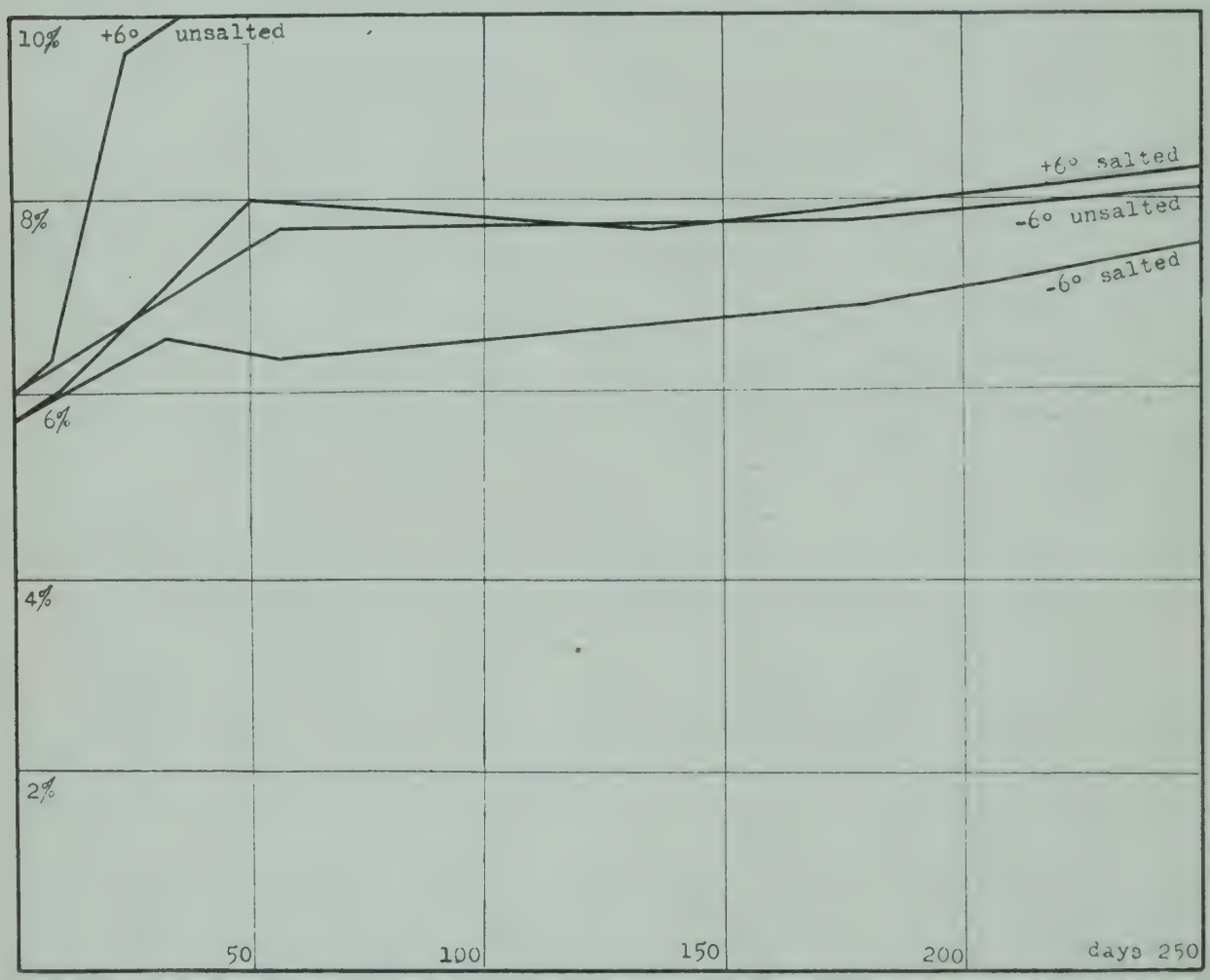


FIG. 4.—Effect of salt and temperature upon the amid nitrogen. Average of three different butters

not include it in any of the averages unless it is especially mentioned.

If we take the averages of the three lots (excluding the warm, unsalted butters), we find a remarkable difference between them, which is illustrated by Figure 5. Lot B, from the creamery with the highest scored butter, has the slightest change. Lot A, scoring a little lower, made from a low quality of cream, has an increased degradation of proteins, and Lot C, the butter with the lowest score, has the largest amount of proteid cleavage products. These curves are very much like those demonstrating the acidity in butter. The lot with the highest acid shows also the largest amount of amido compounds. These two processes will naturally occur in the same proportion in most butters, since both, probably, are directly or indirectly (enzyme action) caused by micro-organisms. Conditions favorable for the one group will usually be favorable for the other also, provided that both are present.

FIG. 5.—Amid nitrogen, averages of lots A, B and C (unsalted sample at + 6° C. not included).

The increase of the "amid-nitrogen" seems much larger if we record it in percentage of the water in butter, and it has been demonstrated before (page 467.) that it is more suitable to record soluble substances in their relation to moisture than to the total butter. In doing so, we obtain Table VI (next page) for the "amid nitrogen" in fresh and old butter.

Figuring, from the data based as indicated, the increase of amid nitrogen in percentage of the original amid nitrogen we find that, in the grand average of all twelve samples (Table VII), there is an increase of 152% of amido compounds. The warm stored samples increased 100% to 400%; the cold storage samples, only 43% to 66%.

We have to discuss, further, the difference in the amount of proteid decomposition products precipitated by the different reagents. Copper sulphate, according to Richmond and Allen, is a strong precipitant of proteins in the presence of a trace of alkali, if added until the alkali is neutralized by the formation of copper hydroxid and until a trace of copper remains in solution. It precipitates casein, hetero-caseose and proto-caseose completely; the copper salt with a-deutero-caseose is soluble in excess, while no precipitate is formed with b-deutero-caseose or caseone. Tannic acid and salt, according to Van Slyke and Hart, fails to precipitate caseone or peptones completely, while phospho-tungstic acid precipitates peptones, and in addition, many of the diamido-compounds. Acetic acid, according to Van Slyke and Hart, Allen and Richmond, precipitates casein and any paranuclein that may

TABLE VI.

Grams of Nitrogen in 100 cc. of the Water in Butter.

No. of sample.		Total.	Fresh.			Eight months old.			
			Not precipitated by			Not precipitated by			
			Copper sulphate.	Tannic acid.	Phospho-tungstic acid.	Copper sulphate.	Tannic acid.	Phospho-tungstic acid.	Acetic acid.
Salted +6°C.....	I.....	.568	.032	.032	.028	.085	.064	.068	.151
	V.....	.555	.025	.031	.025	.047	.044	.046	.104
	IX.....	.417	.031	.033	.023	.063	.054	.047	.138
Average.....		.513	.029	.032	.025	.065	.054	.054	.131
Unsalted +6°C...	II.....	.566	.032	.040	.028	.147	.101	.121	.157
	VI.....	.477	.023	.029	.023	.242	.209	.202	.309
	X.....	.455	.030	.037	.028	.130	.102	.085	.136
Average.....		.499	.028	.035	.026	.173	.137	.136	.201
Salted —6°C.....	III.....	.568	.032	.032	.028	.063	.053	.044	.182
	VII.....	.555	.025	.031	.025	.039	.042	.032	.087
	XI.....	.417	.031	.033	.023	.063	.043	.046	.198
Average.....		.513	.029	.032	.025	.055	.046	.041	.156
Unsalted —6°C...	IV.....	.566	.032	.040	.028	.052	.049	.046	.170
	VIII.....	.477	.023	.029	.023	.040	.036	.036	.119
	XII.....	.455	.030	.037	.028	.052	.042	.032	.123
Average.....		.499	.028	.035	.026	.048	.042	.038	.137

TABLE VII.

Increase of Amid Nitrogen in Old Butter Recorded as Percentage of that in Fresh Butter.

	Not precipitated by			Average.
	Copper sulphate.	Tannic acid.	Phospho-tungstic acid.	
Salted +6°C.....	117%	69%	116%	101%
Unsalted +6°C.....	519%	292%	385%	396%
Salted —6°C.....	89%	44%	64%	66%
Unsalted —6°C.....	72%	20%	36%	43%
Average.....	199%	106%	150%	152%

be present, while the hetero- and proto-caseoses are precipitated incompletely.

A number of analyses were made at different times. They show that the total nitrogen increases slowly, due to the loss of moisture, and that the ammonia remains constant within the limits of error, while there is a larger increase in the nitrogenous compounds left in the filtrate from copper sulphate, tannic acid or phosphotungstic acid.

If we consider that copper sulphate does not precipitate b-deutero-caseose or peptones and that tannic acid precipitates the caseoses completely, it would be expected that tannic acid would give a heavier precipitate with butter proteins than copper sulphate; but, without exception, the nitrogenous compounds in the twelve samples, when fresh, were precipitated more completely with copper sulphate than with tannic acid. However, after the butters were kept in storage for about six months, ten out of the twelve samples showed tannic acid to be the stronger precipitant. This indicates that there are nitrogenous compounds in the early stages of proteid degradation that are precipitated by copper sulphate and not by tannic acid, while in the later stages these compounds or others are changed in composition and are precipitated by tannin and not by copper.

Phosphotungstic acid is a more complete precipitant. The nitrogenous compounds in samples of fresh butter are precipitated almost as completely by copper sulphate as by phosphotungstic acid, but the difference becomes greater as the degradation goes on.

We find that the compounds of nitrogen not precipitated by copper sulphate and also those not precipitated by phosphotungstic acid increase gradually as the butter is kept in storage. Those not precipitated by tannic acid increase, and after a time, decrease, but not below the initial amount as is shown by the curves in Fig. 6. This we cannot explain to our satisfaction. If the proteins were broken up into ammonia and the ammonia escaped, there would be an explanation. In this case, we would expect the ammonia to increase, but analyses show it to remain constant. It also would be expected that, if the compounds not precipitated by tannic acid decreased through the loss of ammonia, those not precipitated by copper sulphate or phosphotungstic acid would decrease; and that there would be a decrease in the total nitrogen. Neither of these results occurred. Is it possible that the degradation products could be synthesized, either chemically by the action of compounds that were formed or were present in the butter, or bacteriologically through the action of micro-organisms and their enzymes? Would not copper sulphate or phosphotungstic acid show this the same as tannic acid? The compounds precipitated by phosphotungstic acid, and not by tannic acid, may be the ones synthesized; if this is the case, then phosphotungstic acid would not show it. But, at the time when the quantity of nitrogenous compounds in the tannic acid filtrate was decreasing, that in the copper sulphate filtrate was increasing and became greater than the former. This view indicates that synthesis is not the cause. Now, Van Slyke in his work with cheddar cheese found that the casein insoluble in five per cent sodium chlorid solution became soluble and then insoluble again. Is it not probable that a similar condition exists here, in that butter proteins in the course of degradation pass through a form that is not precipitated by tannic acid into a form that

is precipitated and then not precipitated again? This decrease in the nitrogenous compounds is brought about probably by a combination of factors and not due to a single cause.

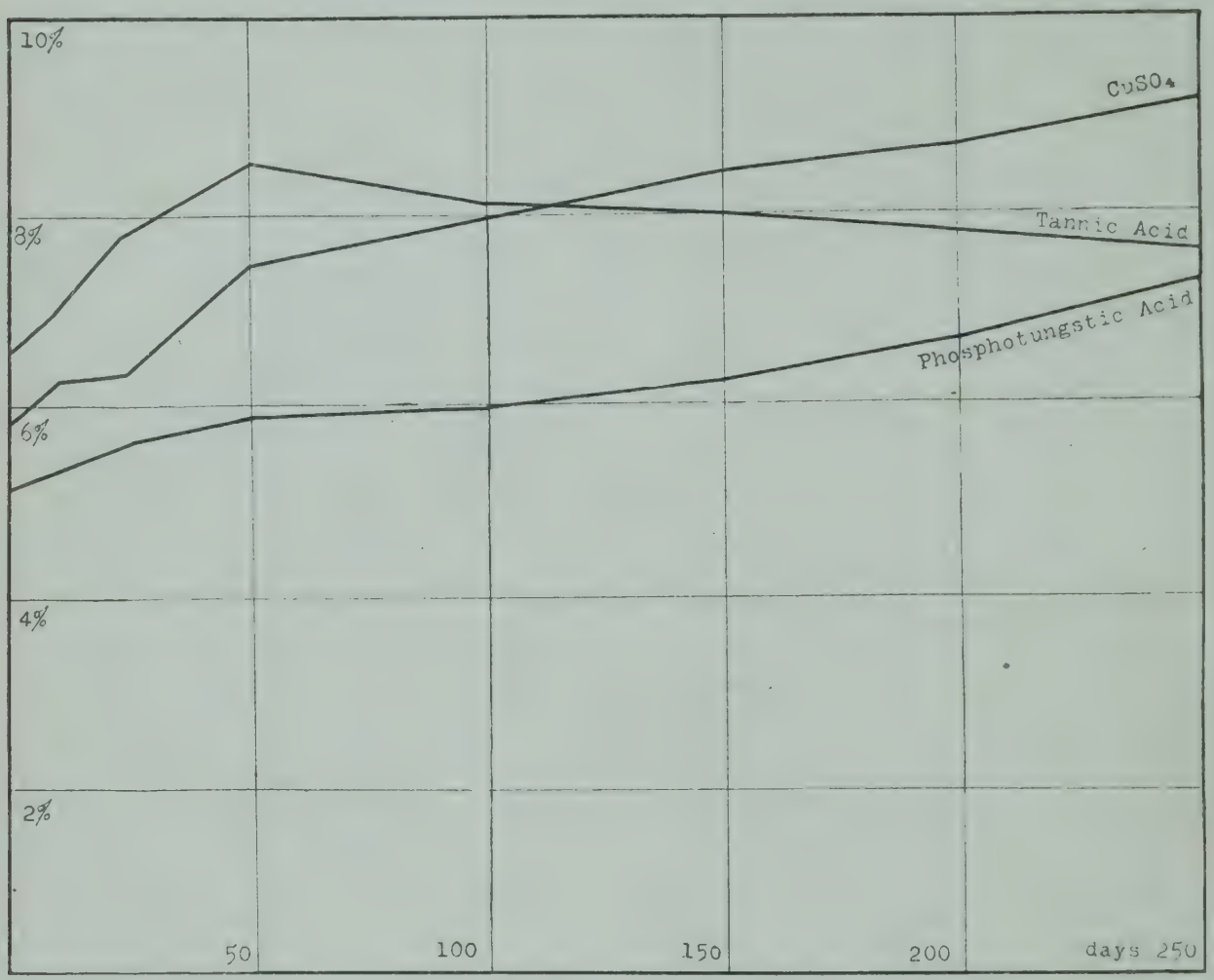


FIG. 6.—Nitrogen not precipitated by copper sulphate, tannic acid and phosphotungstic acid, recorded as percentage of total nitrogen. Each curve represents an average of nine samples (unsalted samples at + 6° C. not included).

TABLE VIII.

Increase in Nonprecipitable Nitrogenous Compounds.

Sample.	Temperature of storage.	Total nitrogen (% of butter).	Nitrogen in form of ammonia (% of total nitrogen).	Per cent of total nitrogen not precipitated (ammonia not included): By phosphotungstic acid.			By copper sulphate.			By acetic acid after 7 to 8 months.
				Fresh butter.	After 7 to 8 months.	Increase.	Fresh butter.	After 7 to 8 months.	Increase.	
No. I.....	+6°C.	.0753	1.99	2.91	6.90	3.99	3.59	9.19	5.60	19.92
No. V.....	+6°C.	.0760	2.11	2.36	4.41	2.05	2.36	4.47	2.11	14.10
No. IX.....	+6°C.	.0648	2.09	3.48	5.64	2.16	5.33	8.26	2.93	22.84
No. III.....	—6°C.	.0753	1.99	2.91	4.38	1.47	3.59	7.17	3.58	26.42
No. VII.....	—6°C.	.0760	2.11	2.36	3.41	1.05	2.36	3.81	1.45	13.16
No. XI.....	—6°C.	.0648	2.09	3.48	6.41	2.93	5.33	9.52	4.19	36.26
No. IV.....	—6°C.	.0732	2.05	2.87	6.29	3.42	3.55	7.37	3.82	30.96
No. VIII.....	—6°C.	.0834	2.16	2.76	4.38	1.62	2.76	5.04	2.28	21.49
No. XII.....	—6°C.	.0720	1.88	4.16	4.86	.70	4.64	8.88	4.24	25.69
Average.....		.0734	2.05	3.03	5.19	2.16	3.72	7.08	3.36	23.42

As an average of nine samples, (Table VIII) 2.05% of the total nitrogen in butter is in the form of ammonia, 3.03% in fresh butter and 5.19% in old butter represents the nitrogen in compounds—not including ammonia—not precipitated by phosphotungstic acid and 3.72% of nitrogen in fresh and 7.08% in old butter is in a form not thrown down by copper sulphate; or there is an increase in the nitrogen non-precipitable by phosphotungstic acid of 2.16% of the total nitrogen present in butter, and of 3.36% not thrown down by copper sulphate—almost double the quantity originally present.

TABLE IX.

Per cent of Total Nitrogen in the Form of Different Compounds.

	Ammonia.	Monoamido compounds.	B-Deutro-caseose, peptones, and diamido compounds.	Hetero- and proto-caseoses.	Casein and paranuclein.
In fresh butter	2.05	3.03	0.69	.....	.....
After 7 to 8 months storage	2.05	5.19	1.89	14.29	76.55
Increase	0	2.16	1.20	.....	.....

If it could be said that phosphotungstic acid leaves in the filtrate monoamido compounds and ammonia only, that copper sulphate leaves b-deutero-casesose, peptones, diamido and monoamido compounds and ammonia and that acetic acid precipitates casein and paranuclein, the nitrogenous compounds in butter would be divided into five parts (See Table IX). However, as the different precipitants do not differentiate sharply between the nitrogenous compounds, Table IX is not absolutely correct; but it gives an estimation of the relation of these compounds to each other.

THE BACTERIAL CONTENT—DECOMPOSITION AND BACTERIAL ACTIVITIES.

The micro-organisms in the butter were counted according to the types of colonies at short intervals. The agar plates were made in the ordinary way (for details see Technical Bul. No. 1, p. 10 of the Michigan Expt. Sta.). In spite of the discouraging results of last year which showed hardly any characteristic bacterial vegetation we decided to try it one year more. In the preliminary experiments, the bacteria were counted in the fresh butter and again after six and nine months. There was a possibility that a slight increase took place in the first months of storage which we did not notice, because, at the time of sampling, the bacteria might have been dead, while their enzymes were active. To avoid this, plates for counting and isolating were made frequently, especially in the first few weeks of storing. By this means, we were less apt to be deceived by an accidental error

in counting and diluting or by meeting an occasional contamination in sampling, because the results control each other.

The identification and the naming of the bacteria were conducted as in our previous work, that is, according to the "Classification of Dairy Bacteria" by Conn, Esten and Stocking. The results are given in the following Table X. The numbers of most of these organisms are so small that we simply state their presence by a + sign. Besides, the numbers, even if they were higher, would not denote anything. If a bacterium is found on the first day to the extent of 50,000 cells per gram, and then is not found again in the following five examinations, but on the sixth examination, it is again found to the extent of 28,000, the conclusion may be drawn that there are a few places in the butter where this organism occurs and perhaps multiplies, but its occurrence may be regarded as too rare to have any significance.

TABLE X.

Micro-organisms in Butter.

Sample I.

Days.	1	4	6	10	18	30	46	60	90	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+	+
Micrococcus lactis aureus									+	
Micrococcus lactis varians			+	+						
Bacillus lactis plicatus	+						+			
Bacterium lactis Connii					+					
Bacterium lactis non acidi						+				
Bacterium lactis aerogenes	+	+	+							
Bacterium lactis catenensis						+				
Bacterium lactis Marshallii	+									
Torula non liquefying				+	+	+	+			
Torula liquefying	+	+	+	+	+	+	+	+	+	+
Torula pink			+			+	+			
Oidium lactis	+	+	+	+	+	+	+	+	+	+
Oidium 2		+	+	+	+	+	+			
Lost cultures		+		+					+	+

Sample II.

Days.	1	4	6	10	18	30	46	60	90	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+	+
Micrococcus lactis acidi				+						
Bacillus subtilis							+			
Bacillus plicatus	+			+				+		
Bacillus non-liquefying non-acid								+		
Bacterium lactis non-acidi						+				
Bacterium lactis aerogenes		+	+							
Bacterium lactis cretaceum							+			
Bacterium lactis Marshallii	+									
Torula non-liquefying				+		+	+	+	+	
Torula liquefying	+	+	+	+	+	+	+	+	+	
Torula pink	+									
Oidium lactis		+	+	+	+	+	+	+	+	+
Oidium 2		+	+	+	+	+			+	
Lost cultures										+

TABLE X.—Continued.

Sample III.

Days.	1	9	26	40	80	100	155	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+
Micrococcus lactis varians		+	+				+	
Micrococcus lactis citreus					+			
Bacillus subtilis				+				
Bacillus plicatus	+							
Bacillus liquefying non-acid					+			
Bacterium lactis Connii			+					
Bacterium lactis aerogenes	+	+						
Bacterium lactis Marshallii	+							
Torula non-liquefying			+	+				
Torula liquefying	+	+	+	+	+	+		
Oidium lactis	+		+	+	+		+	+
Oidium 2	+	+	+		+			

Sample IV.

Days.	1	9	26	40	80	100	155	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+
Micrococcus lactis varians		+						
Micrococcus lactis albus						+		
Galactococcus versicolor				+				
Bacillus subtilis					+			
Bacillus liquefying non-acid				+				
Bacterium lactis aerogenes		+						
Bacterium lactis Marshallii	+				+			
Torula non-liquefying			+	+				
Torula liquefying	+	+	+					
Torula pink	+							
Oidium lactis			+		+			
Oidium 2		+	+					

Sample V.

Days.	1	3	10	18	30	46	60	90	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+
Micrococcus lactis varians	+						+		
Micrococcus lactis citreus			+	+					
Galactococcus versicolor				+					
Bacillus non-liquefying acid	+								
Bacterium lactis Connii	+		+	+			+		
Bacterium lactis Marshallii	+								
Bacterium lactis aerogenes		+							
Bacterium lactis catenensis				+				+	
Bacterium lactis synxanthum								+	
Bacterium liquefying acid				+					
Torula non-liquefying							+		
Torula liquefying			+		+				
Torula pink							+		
Oidium lactis		+				+			
Lost cultures		+				+			+

TABLE X.—Continued.

Sample VI.

Days.	1	3	10	18	30	46	60	90	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+
Micrococcus lactis citreus	+								
Micrococcus lactis varians				+		+			
Micrococcus lactis albidus								+	
Galactoccus versicolor			+						
Bacillus lactis plicatus		+						+	
Bacterium lactis aerogenes	+	+							
Bacterium lactis Connii Var. A			+						
Bacterium lactis cretaceum								+	
Bacterium lactis brevis		+							
Bacterium non-liquefying acid		+							
Torula non-liquefying			+	+	+	+		+	
Torula liquefying			+		+		+		
Torula pink					+	+	+		
Oidium lactis	+	+			+	+	+	+	+

Sample VII.

Days.	1	10	26	40	60	80	100	140	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+
Micrococcus lactis aureus		+							+
Micrococcus lactis varians	+		+		+				
Micrococcus lactis albidus			+				+		
Galactococcus versicolor						+			
Micrococcus non-liquefying acid		+							
Micrococcus non-liquefying non-acid				+					
Bacillus moruloideus								+	
Bacillus subtilis			+	+					
Bacillus liquefying non-acid				+					
Bacterium lactis Connii	+	+							
Bacterium lactis cretaceum				+					

Sample VIII.

Days.	1	10	26	40	60	80	100	140	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+
Micrococcus lactis aureus		+		+				+	
Micrococcus lactis varians			+						
Micrococcus lactis citreus	+				+				
Micrococcus lactis albidus								+	
Bacillus subtilis				+					
Bacillus lactis plicatus				+					
Bacillus non-liquefying acid		+							
Bacterium lactis catenensis						+			
Torula non-liquefying				+					
Lost cultures					+		+		

TABLE X.—*Continued.*

Sample IX.

Days.	1	3	5	11	28	45	65	90	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+
Micrococcus lactis varians	+								
Micrococcus lactis aureus			+				+		
Bacillus lactis plicatus				+					
Bacillus subtilis					+				
Bacterium lactis catenensis		+		+					
Bacterium lactis cretaceum							+		
Torula liquefying	+	+	+	+	+	+	+	+	
Torula non-liquefying		+	+	+		+	+	+	+
Torula pink	+			+	+				
Oidium lactis	+	+	+		+	+	+	+	
Oidium 2	+	+	+		+				
Lost culture	+								

Sample X.

Days.	1	3	5	11	28	45	65	90	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+	+
Micrococcus lactis aureus			+	+					
Micrococcus lactis varians	+					+			
Bacillus lactis plicatus							+		
Bacillus subtilis							+		
Bacillus non-liquefying non-acid					+				
Bacterium lactis fluorescens					+			+	
Torula non-liquefying			+	+		+			
Torula liquefying	+	+	+	+	+	+	+	+	
Torula pink	+					+			
Oidium lactis	+	+	+		+	+	+	+	
Oidium 2	+	+	+						
Lost culture	+								

Sample XI.

Days.	1	9	25	40	60	80	100	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+
Micrococcus lactis varians					+		+	
Micrococcus lactis aureus								+
Bacillus subtilis		+						
Bacterium lactis aerogenes			+					
Bacterium lactis non-acidi				+				
Bacterium lactis cretaceum				+				
Bacterium lactis Connii Var. A					+	+		
Bacterium lactis catenensis						+		
Torula liquefying	+	+	+	+	+	+		+
Torula non-liquefying			+		+			
Torula pink	+		+					
Oidium lactis	+	+	+	+	+			
Oidium 2	+	+	+					

TABLE X.—Concluded.

Sample XII.

Days.	1	9	25	40	60	80	100	180
Bacterium lactis acidi	+	+	+	+	+	+	+	+
Micrococcus lactis aureus	.....	+	.....	.....	.....	.....	.....	.....
Micrococcus lactis citreus	.....	.....	+	.....	.....	.....	.....	.....
Micrococcus lactis varians	+	.....	.....	.....	.....	.....	.....	.....
Bacillus lactis plicatus	.....	.....	+	.....	.....	.....	.....	.....
Bacillus subtilis	.....	.....	+	.....	.....	.....	.....	.....
Bacterium lactis Connii	.....	+	.....	.....	.....	.....	.....	.....
Bacterium lactis non-acidi	.....	.....	.....	+	.....	.....	.....	.....
Bacterium non-liquefying non-acid	.....	.....	.....	.....	.....	.....	.....	+
Torula liquefying	+	+	+	+	+	.....	.....	.....
Torula non-liquefying	.....	+	+	+	.....	.....	.....	.....
Torula pink	+	.....	.....	.....	.....	.....	.....	.....
Oidium lactis	+	+	+	+	.....	.....	.....	.....
Oidium 2	+	+	+	.....	.....	.....	.....	.....
Lost culture	.....	.....	.....	.....	.....	.....	.....	+

There are only four organisms occurring with remarkable frequency; these are the lactic acid bacteria, two torulae and the Oidium lactis. The two torulae are the same as found in our preliminary investigations, called the "rapidly liquefying" and the "small irregular" yeast. The following Table XI gives the average of their numbers in one milligram of the three corresponding samples (I, V, IX, and II, VI, X and III, VII, XI and IV, VIII, XII, respectively). The lactics decrease from the first day of storing, at first rapidly, then more slowly. In accordance with last year's investigations, the decrease in the cold storage samples is larger in the unsalted samples, while above the freezing point the two run parallel, the unsalted samples having at all times about twice as many bacteria as the salted ones.

TABLE XI.

Occurrence of the Most Common Organisms.

(Numbers found in one milligram of butter at different ages measured in days. The numbers are averages of three different butters.)

I. Bacterium lactis acidi.

Days.	1	3	10	15	30	45	60	80	90	100	180
Salted +6°C.	15,500	7,800	4,700	3,500	1,090	530	500	.....	300	.....	90
Unsalted +6°C.	25,000	14,100	9,800	7,200	2,600	1,000	580	.....	550	.....	180
Salted —6°C.	15,500	.....	5,900	.....	3,800	3,200	.....	1,300	.....	1,500	1,000
Unsalted —6°C.	25,000	.....	12,200	.....	5,200	2,800	.....	500	.....	1,000	100

II. Liquefying Torula.

Salted +6°C.	16	7	4	.....	4	11	8	.....	7	.....	0
Unsalted +6°C.	8	10	14	8	17	4	11	.....	117	.....	0
Salted —6°C.	16	.....	7	.....	5	1	.....	1	.....	0	0
Unsalted —6°C.	8	.....	7	.....	4	1	.....	1	.....	0	0

TABLE XI.—*Concluded.*

III. Non-Liquefying Torula.

Salted +6°C.....	0	0	1	1	10	10	15	.....	5	.....	13
Unsalted +6°C...	0	17	11	20	210	73	3	.....	13	.....	0
Salted —6°C.....	0	.....	0	.....	8	13	.....	0	.....	0	0
Unsalted —6°C...	0	.....	7	.....	4	2	.....	0	.....	0	0

IV. Oidium lactis.

Salted +6°C.....	66	33	20	16	37	23	27	.....	90	.....	2
Unsalted +6°C...	8	67	8	16	91	86	210	.....	100	.....	141
Salted —6°C.....	66	.....	33	.....	53	12	.....	16	.....	0	12
Unsalted —6°C...	8	.....	67	.....	40	33	.....	2	.....	0	0

The liquefying torulae occurred frequently in the butter from creameries A and C, while in all the thirty-four investigations of the butter from B, it was found only five times. We could not notice, however, an increase of this organism, except in the unsalted samples at +6°C.

The non-liquefying torulae, however, showed an increase in all butters. The numbers were never very high, but the increase is too pronounced to be overlooked. Naturally, the unsalted warm samples had the highest counts, amounting to 10% of the lactic acid bacteria. The most remarkable fact is that this yeast was not found in the fresh butter and only after about 10 days it appeared on the plates. It seems possible, therefore, that certain micro-organisms are really able

TABLE XII.

Occurrence of non-liquefying torula in one milligram of butter in different storages.

No. of sample.	Fresh, a	+5°C.		—5°C.		—7°C.		—10°C.	
		a_2	a_3	b	e	d	g	c	f
		6 months.	9 months.	6 months.	9 months.	6 months.	9 months.	6 months.	9 months.
II.....	0	10	4	6	0	18	0	88	1
IV.....	4	0	1	4	10	2	1	5	2
VI.....	0	3	0	12	27	1	1	1	3
VIII.....	0	0	0	0	0	1	1	0	1
X.....	0	36	140	88	26	56	45	41	15
XI.....	0	40	0	4	11	0	56	0	0
XIII.....	31	0	6	30	2	8	13	6	8
XIV.....	0	4	3	1	2	0	3	2	3
XV.....	1	0	0	1	0	0	0	0	0
XVI.....	0	20	0	2	0	1	1	0	0
XVII.....	0	528	0	23	7	1	3	1	2
XVIII.....	0	40	5	4	7	3	5	6	1
XIX.....	0	0	1,180	40	700	16	93	2	16
XX.....	0	55	0	2	1	1	0	2	1
XXI.....	0	3,960	2,000	2	6	10	9	0	4
XXII.....	0	0	0	15	0	3	1	2	2
Average.....	2	293	209	15	50	8	14	10	4

to multiply in cold storage butter, salted or unsalted. Our preliminary work shows the same fact, illustrated by Table XII. A number of samples show no increase of the torulae, while others have them in large numbers—the higher the storage temperature the larger the number.

Oidium lactis shows an increase in the unsalted samples, but not in the salted ones. Of course, the counting of molds is very inaccurate, and one cannot draw definite conclusions from these counts concerning the multiplication of Oidium. But our results agree with the statements of a number of bacteriologists (e. g., Jensen, Fettick) that the Oidium is quite sensitive to salt.

Besides the plates kept at +19° C., another set, also in duplicate, was made from each sample and placed in storage at +6° C. The purpose was to give those organisms accustomed to the low temperature a better chance to multiply. Unfortunately, more than half of these plates were lost through contamination by small insects. Those plates which could be counted were too few in number to be compared with the plates kept at room temperature, and a publication of the records, therefore, is unnecessary.

We also plated from the same dilutions used for the ordinary plates, into salt agar, containing just as much salt as the brine in the butter sample. This meant a 12% salt agar for samples I and III, a 19% salt agar for samples V and VII and a 30% or saturated salt agar for the samples IX and XI. From the unsalted butters, no salt agar plates were made. The purpose of these salt agar plates was to ascertain which micro-organisms were able to multiply in the salt concentration usually found in butter. It seems evident that if butter is decomposed by micro-organisms, these must be able to multiply in the butter and, therefore, must stand the salt concentration, since their original number in fresh butter is not high enough to cause an appreciable change. It is possible, however, that the salt does not reach all the smallest buttermilk drops even after careful working, and that organisms may develop readily in these places. It is a fact that the amount of salt varies in different parts of a tub, or even of a print. (Van Slyke and Hart, 1905.)

The plates from sample I on 12% salt agar showed a good growth of various organisms. The lactics did not thrive well and the final count after thirty days showed about 10,000 per gram of butter; the other bacteria also did not develop in larger numbers, while the two torulae grew abundantly, the liquefying torula appearing in about 2,000 cells, and the non-liquefying torula in about 30,000 cells per gram of butter. Oidium lactis was found in about the same number as the non-liquefying yeast. After three months of storage, the butter was plated in a 24% salt-agar and 20,000 cells of the non-liquefying yeast were found per gram of butter.

The plates from sample III, on 12% salt agar, also showed yeasts predominant, the non-liquefying torula occurring in the average number of 10,000 to 20,000 per gram during the first months. No lactics were found on these plates and only a few Oidium colonies.

The samples V and VII were, at first, through a mistake in figuring, plated in agar with 9% salt instead of 19%. This allowed a fairly good growth of all kinds of organisms, the lactics running from 250,000 to

600,000 per gram. When the concentration was changed to the proper 19%, only four colonies appeared on the plates made from one milligram of butter, two of them being yeasts. After the first month of storage, no colonies developed on the plates. This is not surprising, since the butter from creamery B was nearly free from yeasts. The samples IX and XI, plated in saturated salt agar, never gave rise to a colony.

Duplicate sets of the salt agar plates were also placed in cold storage at +6° C. These plates showed a fairly good development of organisms in the first weeks of storage. The development of the colonies was naturally much slower in the salted medium and at this low temperature than on ordinary agar plates, and we allowed the plates to stand for four to five weeks before counting and isolating. In the plates from samples I and III, with 12% of salt, the torulae developed abundantly, while other organisms were not discovered. The highest number counted in I was after eighteen days, amounting to 44,000 cells per gram of butter.

In plating the butter from creamery B, in the 9% salt agar, bacteria developed in large numbers. Torulae could not be found, since this butter was nearly free from them. As soon as we discovered our mistake and raised the salt concentration to the proper 19%, we had an exceedingly poor growth. Plates from one milligram of sample V, eleven days old, showed after forty days of development, four colonies, two of them belonging to the non-liquefying torula, the other two belonging to a yellow and a white bacterium. The eighteen days' old sample gave two bacterial colonies per milligram of butter; the later samples gave no colonies. Sample VII behaved similarly.

The high salt concentration of the butter from creamery C called for a saturated salt agar. We never discovered a colony on these plates. A few experiments which were carried on in the same way, a year ago, gave the same results, either no growth whatever or the non-liquefying torula.

The resistance of this torula to unfavorable conditions as salt and cold and even the two combined, is remarkable. It has been the general belief of bacteriologists that no organism can develop at as low a temperature as —6° C. Here we have a proof that, at least, one organism is able to do this, even if its growth is retarded by salt.

That the torulae are very resistant to salt is a well known fact. The salt yeast of Wehmer, found in the brine of salted herring, is perhaps the oldest example. We have learned through the experiments of Pettersson, on the salting of meat and fish, that the torulae begin to make their appearance at about 15% of salt. At lower concentrations, they are not found, but even at 20 and 23%, they are present. In the pickle factories they grow abundantly on the surface of the brine containing the pickles, often producing a scum one to two centimeters thick. Pure cultures of this torula grow in a 25% salt broth.

Whether this yeast has anything to do with the off-flavor of cold storage butter, is questionable. It occurs in so small numbers, about 10,000 to 50,000 per gram at the highest, that it could hardly cause any material chemical changes. Besides, it grows very slowly in sterile milk, producing no apparent change except a slight alkalinity. But the texture of butter is quite different from that of milk, and changes may

occur under such conditions which never take place in skimmed milk. We have an analogy in soil bacteriology. On the other side, Wehmer believes that the salt yeast may be the cause of the fishy odor of the herring brine. Pettersson claims that the peculiar taste of salted pork and beef is due to a torula.

Only experiments with a pure culture inoculation can decide definitely about the influence of this yeast upon the keeping of butter.

CONCLUSIONS.

Salted butter keeps better than unsalted butter, above the freezing point as well as below.

Salted butter loses more water in storage than unsalted. The loss is not due to evaporation, but to leakage.

Cold storage butter may be very low in score without any noticeable change in acidity.

All butter investigated showed an increase of "amid nitrogen," i. e., nitrogen not precipitated by copper sulphate, tannic acid or phosphotungstic acid. The poorest butter had the highest increase.

There are micro-organisms found in butter, able to multiply slowly at —6° C. in salted butter. Whether these organisms are able to cause deterioration of butter, is not certain.

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FOREWORD.

Technical Bulletin No. 3.

About one year ago the Bureau of Animal Industry turned over to the Experiment Stations and other state institutions the Dorset-Niles method, by demonstration, of manufacturing hog cholera serum, for the purpose of preventing and fighting the disease. This was done to meet the demands of swine-breeders for this serum. Unfortunately, with the transmission of the method came a multitude of unanswered questions and unsettled problems which have materially interfered with the practical application of the treatment and the manufacture of the serum. Of this overwhelming burden of problems the one which has impressed itself upon us more than any other has been the lack of some method by which the potency of the serum can be satisfactorily measured; for prolonged manufacture emphasizes the fact that potency in serum is a most variable quantity. If this is true (our experiences seem to establish it) no serum is fit for use until the potency has been determined. While it is possible to use pigs for this work, they will never be satisfactory because of the great expense involved, the limited number that can be employed for each test, and the likelihood of errors creeping in from inability to control.

With these conditions in mind, the work of this bulletin has been undertaken, hoping to discover some clew to the *actual value* of serum produced for distribution.

The efficiency of the serum is not a matter of dispute, provided its potency can be definitely placed.

CHARLES E. MARSHALL.

STUDIES OF AGGLUTINATION REACTIONS IN HOG CHOLERA DURING THE PROCESS OF SERUM PRODUCTION.

GENERAL DISCUSSION.

It does not seem advisable to ignore the part played by B. cholerae suis in hog cholera infection, even though we assume that the primary etiological factor in the great swine epizoötics in this country is a filterable, ultramicroscopic organism. Whatever the relation may be between the filterable virus and B. cholerae suis and hog cholera, for the three appear to be almost, if not quite, constantly associated, we cannot fail to recognize the immense value that has accrued to serum therapy in hog cholera as a result of the partial abandonment of the formerly accepted etiological relation of B. cholerae suis to hog cholera.

The immunizing serum prepared according to the Turner-Kolle method is aimed at the protection of hogs from the ultramicroscopic virus. Connaway[1] believed that in the process of hyperimmunization he could also impart to the immunizing serum protective properties against B. cholerae suis by feeding the viscera of hog cholera or virus hogs. This is a tacit admission that the Dorset-Niles immunizing serum is not, at least, necessarily, potent to protect swine against B. cholerae suis infection. The process of hyperimmunization might appear to furnish ample proof of the immunity against B. cholerae suis in hogs immunized against the filterable virus. In this process, the immune hogs are injected with enormous quantities of virus blood either intravenously, or intramuscularly, and are frequently fed the diseased meat and viscera, so that they must receive into their system great numbers of B. cholerae suis and do not suffer the fatal results that would attend the introduction of a similar number of the same species of bacteria into the system of non-immune hogs.

On the other hand, it has been shown by Dorset, Bolton and McBryde[2] that resistance toward certain methods of exposure to B. cholerae suis in no way indicates immunity to the filterable virus. Notwithstanding this apparent demonstration of the non-identity of the two virus, there is still an unexplained intimate relation between hog cholera and B. cholerae suis.

If it can be demonstrated that the easily handled B. cholerae suis has a constant and intimate relation to hog cholera infection and to the immunizing serum, it has occurred to us that this fact, if a fact, might be used in some laboratory method by which the potency of the serum and perhaps of the virus could be estimated in vitro. At present, only biological tests, limited in their application to pigs, are available. These tests are expensive, not without objection as to accuracy, and require a long time for the development of results.

The object in the agglutination tests was to determine the relation, if any, between the phenomenon of agglutination of B. cholerae suis and the virulence of hog cholera virus or potency of immunizing serum. It is not to be inferred from the above statement that we interpret the agglutination reaction as a reliable means of measuring either the degree of immunity or infection in any or all infectious diseases where this test has been applied; but there are cases recorded[3] in which the agglutinative power of serum and its opsonizing and bactericidal power increase simultaneously. It is true, likewise, that there are records which fail to show this comparison. The technic involved in the agglutination test is simpler and the results are more easily interpreted than in any tests for determining the opsonizing or bactericidal power of serum. The work of Bolton[4] on the bacteriolytic power of hog serum does not encourage one to expect uniform results in this connection, though its repetition here would be interesting and perhaps of far-reaching significance. We are satisfied that the results of our experiments add to the sum of our knowledge of the subject covered in the title of this paper, even if we have failed in demonstrating a method wholly satisfactory at this moment for standardizing the potency of hog cholera virus and serum.

PREVIOUS WORK.

The very recent introduction of the Dorset-Niles hog cholera serum together with our present attitude toward B. cholerae suis as a factor in the production of hog cholera preclude the possibility of a very extensive literature on the agglutination of that organism in connection with serum production.

The agglutination of bacteria has long been recognized as a phenomenon having more or less significance in the diagnosis of specific infectious diseases and in the identification of specific pathogenic bacteria. The similarity of B. cholerae suis to B. typhosus and the similarity of the disease formerly supposed to be due to the former organism, and the disease at present attributed to the latter organism has stimulated a few workers with hog cholera to apply the Widal test or some modification of it to that disease.

McClintock, Boxmeyer and Siffer[5] have reviewed the literature on agglutination in hog cholera and note that Dinwiddie[6] is the only one they are able to find who has applied the test with the blood of diseased hogs. Dawson[7] and Smith[8] found that the blood of vaccinated rabbits often agglutinated in high dilutions. The treatment of animals with B. cholerae suis appears to result in the production of agglutinins for that organism. Dinwiddie's results were all negative but no hog cholera bacilli were isolated from the pigs furnishing the tested serum.

The work of McClintock, Boxmeyer, and Siffer is more exhaustive and fruitful in its results. They used suspensions of agar cultures in chloretone and the macroscopic method. The tubes were examined for the last time 20 hours after making the dilutions. The presence of "plain floccules" constituted a positive reaction. They state that bacterial suspensions remain fit for use for several weeks. The reaction varied in intensity with the strain of B. cholerae suis used. Some of their conclusions, based upon a rather limited number of tests, are as follows:

"1. The serum of normal hogs agglutinates strains of ordinary hog cholera bacilli in dilutions occasionally as high as 1 to 250.

. . . . . .

"3. Agglutination is of no value for the diagnosis of hog cholera, as the disease is at present defined.

"4. The presence of a positive reaction does, however, indicate an infection with the hog cholera bacilli.

"5. There are occasional instances of both natural and artificial infection in which no increase of the agglutinins for hog cholera over those normally present can be demonstrated.

"6. The maximum amount of agglutinin develops in a hog's blood within six or seven days after a single inoculation with hog cholera vaccine.

"7. Hogs react to intraperitoneal injections of hog cholera vaccines, usually with the production of large quantities of agglutinins, the amount of the vaccine bearing no relation to the amount of agglutinin produced."

Uhlenhuth[9] and his associates have made extensive researches into certain phases of agglutination with the purpose to designate the etiological factors at work in hog cholera, while it has been our aim to measure the potency of hyperimmune serum by means of agglutination.

METHODS AND REACTIONS.

I. The Agglutination Test.

In our agglutination tests we have used the macroscopic method developed during the study of the agglutination reactions in the diagnosis of glanders[10] and modified to meet the requirements of the present work. An emulsion was prepared by washing off the growth on agar slants with .5% carbolic acid in physiological salt solution. The growth on agar was 24 to 48 hours old at 37° C. and was killed by 15 minutes exposure to 60° C. in water bath. This emulsion was filtered several times through cotton and greatly diluted with carbol-salt solution. In each of a series of test tubes was placed 4 cc. of this faintly cloudy bacterial suspension to which was added blood serum in varying quantities to make the different dilutions. A tube of bacterial suspension without the serum served as a check in each test. The tubes were then incubated 48 hours at 37° C. A positive reaction, according to our interpretation, consisted in, first, the clumping of the dead germs in greater or smaller flocculent masses of macroscopic size, which later fell to the bottom of the tube forming a membrane of agglutinated germs spreading over the whole hemispherical bottom of the tube, leaving the supernatant fluid more or less clear. Of course, the reaction varied in intensity with the different sera and with the degree of dilutions.

In studying the reaction, then, we take into consideration two factors, viz,—(a), The clumping or agglutination of the bacteria and consequent clearing of the test fluid and (b), The formation of a characteristic membrane on the bottom of the tube.

There was never any reaction in the check tubes, although there was usually a slight, finely granular sediment consisting of non-agglutinated bacteria that naturally settled to the extreme bottom of the tube. The time limit was 48 hours, as a rule, for the reaction was not always com-

plete until this time in the higher dilutions and there was usually no tendency for the process to progress after this time. Frequently, in the lower dilutions or with a strongly agglutinating serum, the reaction would be complete in less than 24 hours. The agglutinated masses of bacteria were macroscopic in size and remained suspended in the fluid some time after formation. In some cases, while there was an abundant flocculent sediment of agglutinated bacteria, there were still many non-agglutinated bacteria in suspension as shown by both macroscopic and microscopic observations. This may be accounted for by the fact that the emulsion of bacteria was too dense, i. e., the test fluid contained too many bacteria in suspension as a consequence of which the agglutinin in the serum diluted above 1—250 was exhausted after having agglutinated a portion of the dead bacteria as great in amount as was ordinarily present in the bacterial suspension for the other tests. The matter of diluting the bacterial suspension to just the proper degree of cloudiness is not at all simple. A hanging drop of the test fluid gives some idea of the number of bacteria present, but an efficient method of determining the proper dilution has not yet been formulated.

II. Drawing and Preparing the Blood.

The blood from the normal and serum pigs was drawn from the tail after the methods devised by Niles[2]; that from the virus hogs, from the throat when these pigs were killed. In each case, except where otherwise stated, the blood was defibrinated by whipping and allowed to stand at a low temperature (about 10° C.) until the corpuscles settled leaving a clear, amber-colored or haemoglobin-stained serum above. The presence of erythrocytes or excess of haemoglobin in the serum did not prevent the agglutination, but masked the appearance so that it was difficult to judge accurately the degree of reaction.

NON-VIRULENT CULTURE.

The Manistee Culture.

Our initial experiments with B. cholerae suis proved interesting in many respects, but were possibly of less value, because of the absence of virulence in the culture used. The "Manistee culture" had been used several months before and had produced quite uniform results, killing rabbits in very small doses; pigs injected intravenously and frequently intramuscularly, died with extensive hemorrhagic lesions.

The following inoculation experiments show the former virulence and the lack of virulence of the "Manistee culture" at this time:

I. VIRULENCE.*

Nov. 27, 1907, inoculated six 25 lb. pigs into femoral artery with a 42 hr. bouillon culture (Manistee) grown at 37° C. as follows:

Two with 2 cc. each, Series 50, Nos. 11 and 12.
Two with 1.5 cc. each, Series 50, Nos. 13 and 14.
Two with 1 cc. each, Series 50, Nos. 15 and 16.

Series 50, No. 11, showed a rise in temperature to 105.2°.
Died about 85 hours after inoculation.

* Only a few typical cases are cited here from the large number of inoculations with the "Manistee culture" at the time of its virulence.

Autopsy: Skin over ventral aspect and on inside of legs, hyperaemic; lungs hyperaemic, a few hepatized lobules and hemorrhagic areas; heart cavities filled with clotted blood; liver shows coagulation necrosis over surface; spleen, enlarged, dark red; kidneys, congested and swollen; stomach shows a patch of mucous membrane very highly inflamed and diphtheritic with an ulcerous patch and many small ulcers about its border; walls of small intestine, thickened and covered with catarrhal exudate; large intestine shows highly inflamed patches, purplish red in color; lymphatic glands, hemorrhagic and engorged.

Series 50, No. 12, showed a rise of temperature to 105°.

Died about 80 hours after inoculation.

Autopsy: Hyperaemic condition of skin over ventral aspect and inside of legs; lymph glands, generally hemorrhagic in cortex; lungs, hyperaemic, with scattered hemorrhagic and hepatized areas; heart, full of clotted blood; few sub-epicardial petechiae; liver shows coagulation necrosis; spleen, engorged, dark red; stomach shows ecchymoses and ulceration in mucosa; small and large intestines show hemorrhages in mucosa.

Series 50, No. 13, showed rise in temperature to 105.3°.

Died about 94 hours after inoculation.

Autopsy: Skin hyperaemic over ventral aspect and on inside of legs; lymph glands, generally hemorrhagic in cortex; lungs, generally hyperaemic with scattered hemorrhagic and hepatized areas; heart, filled with clotted blood, with few sub-epicardial petechiae; liver shows coagulation necrosis; spleen, enlarged and dark, purplish red; kidneys show hemorrhages in cortex; small patch of gastric mucosa, inflamed; small intestine shows inflammation and catarrhal exudate with hemorrhagic patches; large intestine shows scattered hemorrhagic patches.

Series 50, No. 14, showed rise of temperature to 106.4°.

Died 6 days after inoculation.

Autopsy: Skin, hyperaemic over ventral aspect and on inside of legs; lymph glands, generally hemorrhagic in the cortex; lungs, hyperaemic, right lung hemorrhagic in large areas, left, petechiated; heart, filled with dark, clotted blood, shows sub-epicardial petechiae; liver shows coagulation necrosis; spleen, enlarged, engorged and purplish red in color; fundus of stomach, greatly reddened, numerous petechiae; large intestine shows catarrhal inflammation, and numerous petechiae; large intestine shows various sized hemorrhages throughout and ulcers in colon near rectum; kidneys show numerous petechiae in cortex.

Series 50, No. 15, showed a rise of temperature to 107° on third day with fluctuating temperatures thereafter from normal to 105.6° until death.

Died 38 days after inoculation.

Autopsy: Lymph glands, generally hemorrhagic in cortex; lungs, hyperaemic, extensive hemorrhagic patches and few hepatized lobules; heart contains clotted blood and numerous sub-epicardial petechiae; liver shows extensive coagulation necrosis; spleen, enlarged, engorged and dark red in color; kidneys, show petechiae in cortex; fundus of stomach, hemorrhagic and ulcerated; few petechiae and ecchymoses in small intestine; button ulcers throughout large intestine.

Series 50, No. 16, showed rise of temperature to 105.8°.

Died 9 days after inoculation.

Autopsy: Skin over ventral aspect and inside of legs, greatly reddened, due to subcutaneous hemorrhage; lymph glands, generally hemorrhagic on cortex; lungs, hyperaemic and greatly hemorrhagic, with few patches of hepatization; clotted blood in heart with numerous sub-epicardial hemorrhages; liver shows coagulation necrosis; spleen enlarged, engorged, and dark purple in color; kidneys show numerous petechiae in cortex; fundus of stomach, hemorrhagic and ulcerated; catarrhal inflammation of small intestine and numerous petechiae throughout; large intestine shows very numerous petechiae and small ulcers.

NOTE.—For the notes on pigs in Series 50, showing the virulence of the "Manistee culture," I have to thank Dr. Marshall to whom I am also greatly indebted for many helpful suggestions in the planning and execution of this work.

Dr. Marshall suspects that the loss of virulence in the "Manistee culture" may be due to the fact that it was transferred from bouillon to bouillon at too prolonged intervals and thus propagated instead of on some more favorable medium with shorter intervals of transfer.

II. NON-VIRULENCE.

(a) *Untreated Animals*—

Our inoculations were made about fourteen months after those described above.

Rabbit 20. Full grown; Feb. 4, 1909, a. m., injected intraperitoneally 0.1 cc. 40 hr. bouillon culture grown at 37° C. Remained well.

Rabbit 21. Full grown; Feb. 4, 1909, a. m., injected intraperitoneally 0.5 cc. 40 hr. bouillon culture grown at 37° C. Remained well.

CLASSIFICATION OF PIGS.*

Expt. pig 147, Chester White; weight, 54 lbs.; no previous treatment. Feb. 24, 1909, injected 2 cc. 40 hr. bouillon culture grown at 37° C. in ear vein. Remained well.

Expt. pig 148, Chester White; weight, 68 lbs.; no previous treatment. Feb. 24, 1909, injected 3 cc. 40 hr. bouillon culture grown at 37° C. in ear vein. Remained well.

Expt. pig 149, Chester White; weight, 48 lbs.; no previous treatment. Feb. 24, 1909, injected 5 cc. 40 hr. bouillon culture grown at 37° C. in ear vein. Remained well.

(b) *Treated Animals*—

Expt. pig 24, weight, 50 lbs.; immunized with 10 cc. mixed serum 15 and 1 cc. virus 59, Nov. 25, 1908. On Feb. 12, 1909, injected 1.8 cc. of a 48 hr. culture in ear vein. Remained well.

Expt. pig 34, weight, 50 lbs.; immunized with 10 cc. mixed serum 16 and 1 cc. virus, Expt. 26, Dec. 3, 1908. On Feb. 12, 1909, injected intraperitoneally 4 cc. of a 48 hr. bouillon culture. Remained well.

Expt. pig 97, weight, 50 lbs.; immunized with 15 cc. mixed serum 15 on Dec. 19, 1908. Injected 1 cc. virus, Expt. 69 on Dec. 28, 1908; 2.5 cc. virus, Expt. 120 on Jan. 18, 1909. On Feb. 12, 1909, injected 2 cc. of a 48 hr. bouillon culture in ear vein. Remained well.

Expt. pig 112, weight, 50 lbs.; immunized with 15 cc. mixed serum 17 and 1 cc. virus 62 on Jan. 5, 1909. Injected 1 cc. virus, Expt. 123 on Jan. 26, 1909 and 2.5 cc. virus, Expt. 141 on Feb. 11, 1909. On Feb. 18, 1909, injected 3 cc. of a 24 hr. bouillon culture in the ear vein and 1 cc. in the perivascular tissue. Remained well.

The lack of virulence or even slight pathogenic properties in this "Manistee culture" is worthy of comment, as it illustrates how cultures of B. cholerae suis lose their virulence when removed from the body of pigs. The tests made with a non-virulent culture will be valuable for comparison with later tests with a virulent culture from one of our virus hogs.

In the table under each dilution are the signs arranged in two columns to indicate the degree of reaction having reference to the two factors considered above. (See page 7.)

* To avoid confusion, it is well to bear in mind the features which distinguish the several classes of pigs referred to in the autopsy notes and tables and in the discussions.

A virus pig is one that has received some treatment, usually intravenous or intramuscular injection of blood from a sick hog, for the purpose of producing in that pig hog cholera.

An immune pig is one that has passed through the disease and is at the time resistant to further treatment sufficient to produce the disease in susceptible animals, or one that has resisted exposure to the disease without becoming sick—natural immunity, or one that has been artificially immunized either by the so-called "Serum-simultaneous" or "Serum-alone" methods.

A serum pig, or hyperimmune pig, is an immune pig that has been treated with intramuscular or intravenous injections of virus, i. e., blood from a virus hog, until there is produced in the blood of the treated pig protective substances,—immunizing serum, against hog cholera.

The virus and serum pigs have been used in the routine work of producing immunizing serum for use in combating hog cholera throughout the state.

An experimental pig is one that has been used for any experimental work in connection with hog cholera. The experimental pigs may have been virus, immune or hyperimmune pigs or they may have been used in tests with cultures of B. cholerae suis.

TABLE I.

Showing agglutination tests with "Manistee Culture" and blood from normal, virus and serum hogs.

In the table, the sign (+) indicates a complete reaction, the sign (−) indicates that the reaction has progressed considerably, but not completely, and the sign (0) indicates no change.

Dilution of blood serum.			1-10		1-25		1-50		1-100		1-125		1-200		1-250		1-333		1-500		1-700		1-1000	
Source of blood serum tested.	Classification of pigs tested.	Method of securing blood.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Seciment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.
Expt. pig 144	Normal	From tail	+	+	+	+	+	+	+	+	+	−	0	0	0	0	0	0	0	0	−	0	0	0
Expt. pig 145	Normal	From tail	+	+	+	+	+	+	+	+	+	−	0	0	0	0	0	0	0	0	0	0	0	0
Expt. pig 146	Normal	From tail	+	+	+	+	+	+	+	+	+	−	0	0	0	0	0	0	0	0	0	0	0	0
Serum pig 76	Hyperimmune	1st tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	−	0	0	0	0	0	0	0	0
Serum pig 80	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	−	0	0	0	0	0	0	0	0
Serum pig 81	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	+	+	−
Serum pig 81	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
Serum pig 83	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
Serum pig 83	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0	0	0	0	0	0
Serum pig 84	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
Serum pig 85	Hyperimmune	1st tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−
Serum pig 87	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Serum pig 87	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0	0	0	0
Virus pig 63	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	0	0	0	0
Expt. pig 137	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−
Expt. pig 138	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	−	+	−	+	−	+
Expt. pig 139	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	+	−	+	−	+	−	+
Expt. pig 140	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−	−	−	0	0
Expt. pig 141	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	0	0
Expt. pig 144*	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0	0	0	0
Expt. pig 145*	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	−	−	0	0	0	0
Expt. pig 146*	Sick, hog cholera	Pig killed	+	+	+	+	+	+	+	+	−	−	−	−	−	−	−	−	0	0	0	0	0	0

* These three pigs are the three normal pigs included in the table after being inoculated with hog cholera virus.

SUMMARY OF TABLE I.

A total of 22 tests were made as follows:

Kind of blood tested.	No. of tests.	No. of pigs.
Normal pig's blood	3	3
Immunizing blood from serum or hyperimmune hogs	10	7
Virus blood from inoculated pigs	9	9
Totals	22	19

NORMAL BLOOD.

Of the normal blood the highest and lowest maximum dilutions at which agglutination occurred were the same in all cases:

Three cases or 100% at 1—125.

IMMUNIZING BLOOD.

Of the immunizing blood, the highest maximum dilution at which agglutinations occurred was:

Six cases or 60% at 1—1000.*

The lowest maximum dilution at which agglutination occurred was:

Two cases or 20% at 1—250.

One case or 10% agglutinated at 1—333.

One case or 10% agglutinated at 1—500.

VIRUS BLOOD.

Of the virus blood the highest maximum dilution at which agglutination occurred was:

Three cases or 33 1/3%, 1—1000.

The lowest maximum dilution at which agglutination occurred was:

One case or 11 1/9%, 1—333.

Three cases or 33 1/3% agglutinated at 1—500.

Two cases or 22 2/9% agglutinated at 1—700.

DISCUSSION OF TABLE I.

These tests, therefore, indicate that there is a considerable increase in the agglutinative power for B. cholerae suis in the blood of serum and virus hogs treated according to the Turner-Kolle method, and that in serum hogs there is usually a greater production of agglutinin than in virus hogs.

VIRULENT CULTURE.

Culture "No. 2, Rab. 25."

Our preliminary tests proved very valuable in suggesting details for more extended investigations along similar lines. Whatever conclusions we deduce from the foregoing experiments, must be looked upon as

* Unfortunately, dilutions higher than 1-1000 were not made until later in the work. On account of this fact, it is not possible in some cases to state exactly what is the maximum dilution at which agglutination would have occurred.

tentative or only as indications of what may be applicable in a general way.

In continuing our experiments, we attempted at the outset to secure a culture of B. cholerae suis from one of our virus hogs that would prove highly virulent.

The plan of our work was to establish the susceptibility of normal and immunized hogs and rabbits to different methods of administering a culture of B. cholerae suis from a virus hog and then to demonstrate the agglutinative power of normal, immune and virus blood for this germ.

SOURCE OF CULTURE.

The culture used in this work was obtained from the spleen of Expt. pig 146, brief clinical and autopsy notes on which are as follows: Susceptible, Chester White pig; wt. 63 lbs.; Feb. 22, 1909, bled from tail about 50 cc. for agglutination test with "Manistee culture." March 1, 1909, injected 1 cc. virus 63 in ear vein and 1 cc. in perivascular tissue. Quite sick by seventh day; weak, no appetite. Killed on the eighth day after injection. Autopsy: Slight blush of skin over ventral aspect; inguinal, iliac, and renal glands hemorrhagic in cortex, portal glands oedematous; spleen, slightly enlarged; kidneys, greatly enlarged, soft and flabby; pale in cortex with few faint petechiae, papillae greatly reddened, small cyst in left kidney; liver engorged with blood, with greatly congested areas under capsule; lungs congested, hemorrhagic in ventral and cephalic lobes.

Pieces of spleen, the size of a pea, produced vigorous growth in bouillon. Cultural tests showed pure culture of B. cholerae suis. Rabbit 25, inoculated with 1 cc. of a 20-hour bouillon culture intraperitoneally, March 13, 1909, died March 16, 1909.

Autopsy: Lungs, greatly congested and slightly hemorrhagic in dependent anterior lobules; spleen greatly enlarged, dark and friable; liver enlarged and gorged with blood; kidneys enlarged and congested. Smears from spleen stained with carbol-fuchsin showed few irregular staining rod-shaped organisms which proved to be pure culture of B. cholerae suis upon cultural tests.

Cultures 1, 2, and 3 were taken from three different colonies on agar plates. Cultures 1 and 2 killed rabbits in four days and culture 3 killed a rabbit in 5 days and grew less vigorously in all culture media. Culture 2, designated "No. 2, Rab. 25," was used in the following experiments:

INOCULATIONS.

(a) *Untreated animals—*

Expt. pig 169, wt., 81 lbs., not exposed to any previous infection or subjected to any other treatment. On March 31, 1909, fed 100 cc. of a 24 hr. bouillon culture "No. 2 Rab. 25," after 24 hrs. fasting. Apr. 4, 1909, or four days after feeding, pig died. Had diarrhoea, no appetite and appeared sick day following ingestion of culture.

Autopsy: All lymph glands very slightly hemorrhagic in cortex; spleen enlarged, dark and friable; liver very friable, parboiled appearance, necrotic spots show on surface; intestines congested throughout; large intestine nearly empty, except for dry, yellowish ingesta firmly adherent to mucous ridges, mucosa shows superficial necrosis; fibrinous exudate on serosa; lungs greatly congested.

Expt. pig 165, wt., 45 lbs.; not exposed to any previous infection or subjected to any other treatment. On March 23, 1909, injected 3 cc. 24 hr. bouillon culture "No. 2 Rab. 25" in ear vein. On March 25, 1909, or in less than 48 hrs., dead.

Autopsy: Skin over ventral aspect, purple; external inguinal, iliac, mediastinal, and portal glands hemorrhagic throughout; spleen greatly enlarged, dark and friable; kidneys firm and normal in color and size with few petechiae showing on surface; liver gorged with blood, bluish in color; lungs greatly congested; left ventricle in systole, right filled with fluid blood.

(b) *Treated animals—*

Experiments with pigs immunized with hog cholera serum or virus:

Expt. pigs 112 and 118 were immunized by the serum-simultaneous method Jan. 5, 1909, the former receiving 15 cc., and the latter, 30 cc. mixed serum 17, and each 1 cc. of virus 62. Jan. 26, 1909, each received 1 cc. virus Expt. 123, and again on Feb. 11, 1909, each received 2.5 cc. virus Expt. 141. No. 112 gained from 21 lbs. to 52 lbs. and No 118 from 21 lbs to 47 lbs. by March, when each pig received 3 cc. of a 24 hr. bouillon culture "No. 2 Rab. 25," in the ear vein. They both remained perfectly well and vigorous, although the distal portion of the injected ear of No. 112 became hemorrhagic, showed dry gangrene in about ten days and eventually sloughed off, leaving a healthy line of demarcation with the unaffected portion of the ear. This probably indicates a general immunity with local susceptibility. On Apr. 8, 1909, each pig was fed 50 cc. of a 24 hr. bouillon culture "No. 2 Rab. 25." Each ate all of it and remained well. On May 1, 1909, in company with four other smaller pigs, one of which did not eat, these two pigs were fed after a 24 hr. fast, 400 cc. of culture "No. 2 Rab. 25" in Dunham's peptone solution grown 48 hrs. at 37° C. and 24 hrs. at room temperature. It is safe to say that each of these two pigs ate at least 100 cc. of the culture.

There was no indication of bad results.

Expt. pigs 107, 113 and 115, weighing about 20 lbs. each, were immunized by the serum-simultaneous method Jan. 5, 1909, Expt. 107 receiving 5 cc. mixed serum 17 and the two latter, 15 cc. each, and each 1 cc. virus 62. On Jan. 26, 1909, each pig received 1 cc. virus Expt. 123 and on Feb. 11, 1909, each received 2.5 cc. virus Expt. 141 in the muscles on inside of thigh. At this time, Expt. 107 was suffering from dyspnoea and ate very irregularly. April 6, 1909, Expt. 107; wt., 39 lbs., and Expt. 115, wt., 35 lbs., were fed 100 cc. each of a 24 hr. bouillon culture No. 2 Rab. 25." The former ate part immediately and the remainder during the night; the latter ate all of it immediately. No evidences of sickness were noted. On Apr. 17, 1909, after fasting 24 hrs., Expt. pigs 107 and 115 were fed each 50 cc. of a 24 hr. bouillon culture "No. 2 Rab. 25." The former ate none; the latter, all of it without producing any signs of sickness. May 1, 1909, all three pigs were fed, in connection with Expt. pigs 112, 118 and 24, 400 cc. of culture "No. 2 Rab. 25," as indicated in notes on Expt. pigs 112 and 118 above. Expt. 107 ate none, the others ate greedily. None of these pigs was affected by feeding cultures under the above conditions.

Before the first feeding experiment, as mentioned above, Expt. 107 was not in a perfectly healthy condition, dyspnoea being the probable cause of unthriftiness. In order to determine the cause of the dyspnoea and ascertain what effect all previous treatment had produced on the various organs of the body, Expt. 107 was bled to death May 7, 1909.

Autopsy: Oedema of glottis producing partial occlusion of larynx; few necrotic foci in hepatized cephalic and ventral lobes of both lungs; liver, very light in color and showed considerable increase in interlobular connective tissue; cholecyst distended with semi-solid, greenish bile; ascarides numerous. Nothing found that could be directly attributed to any portion of the treatment.

In the table under each dilution are the signs arranged in two columns to indicate the degree of reaction having reference to the two factors sidered above. (See page 7.)

TABLE II.

Showing agglutination tests with Culture "No. 2 Rab. 25" on immune, hyperimmune and virus hogs.

In the table, the sign (+) indicates a complete reaction, the sign (−) indicates that the reaction has progressed considerably, but not completely, and the sign (0) indicates no change.

Dilution of blood serum.			1–10		1–25		1–50		1–100		1–250		1–500		1–1000		1–2000	
Source of blood serum tested.	Classification of pigs tested.	Method of securing blood.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.		
Expt. pig 107	Immune	Killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	....	....
Virus pig 79	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	+	−	−	+	0	0	....	....
Virus pig 80	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	+	−	0	0	0	0	....	....
Virus pig 83	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	+	−	−	−	0	0	....	....
Virus pig 84	Sick, hog cholera	Killed	+	+	+	+	+	+	0	0	0	0	0	0	0	0	....	....
Virus pig 85	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	0	+	−	−	0	0	....	....
Virus pig 86	Sick, hog cholera	Killed	+	+	+	+	+	+	−	−	0	0	−	−	0	0	....	....
Virus pig 87	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	+	+	−	−	0	0	....	....
Expt. pig 197	Sick, hog cholera	Killed	+	+	+	+	+	+	−	−	0	0	0	0	0	0	....	....
Expt. pig 199	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	−	−	0	0	0	0	....	....
Virus pig 88	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	0	0	0	0	0	0	....	....
Virus pig 90	Sick, hog cholera	Killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	....	....
Serum pig 89	Hyperimmune	1st tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	−	−	....	....
Serum pig 89	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	−	−	....	....
Serum pig 89	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	−	−	....	....
Serum pig 90	Hyperimmune	1st tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	−	−	....	....
Serum pig 90	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	−	−	0	0	....	....
Serum pig 90	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	−	−	0	0	....	....
Serum pig 93	Hyperimmune	1st tail bleeding	+	+	+	+	+	+	+	+	+	+	−	−	0	0	....	....
Serum pig 93	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	−	−	0	0	....	....
Serum pig 93	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	−	−	0	0	....	....
Serum pig 95	Hyperimmune	1st tail bleeding	+	+	+	+	+	+	+	+	+	+	−	−	0	0	0	0
Serum pig 95	Hyperimmune	Killed	+	+	+	+	+	+	+	+	+	+	+	+	−	−	....	....
Serum pig 96	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	−	−	0	0	....	....
Serum pig 96	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	0	0	....	....
Serum pig 97	Hyperimmune	3rd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	0	0	0	0
Serum pig 97	Hyperimmune	Killed	+	+	+	+	+	+	+	+	+	+	+	+	−	−	....	....
Serum pig 109	Hyperimmune	Killed	+	+	+	+	+	+	+	+	+	+	+	+	+	+	0	0
Serum pig 117	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	....	....
Serum pig 118	Hyperimmune	2nd tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Serum pig 119	Hyperimmune	1st tail bleeding	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

Having secured a culture of B. cholerae suis that promised considerable pathogenic power for untreated pigs and little or no pathogenicity for serum-immunized pigs, we continued our agglutination experiments along the same line as before. Table II shows the results of the tests with culture "No. 2, Rab. 25," and serum from immune, virus, and hyperimmune hogs.

SUMMARY OF TABLE II.

A total of 31 tests were made as follows:

Kind of blood tested.	No. of tests.	No. of pigs.
Blood from immune pigs	1	1
Virus blood from inoculated pigs	11	11
Immunizing blood from serum or hyperimmune pigs.	19	10
Total	31	22

BLOOD FROM IMMUNE PIG.

Expt. pig 107 is classed as an immune, but the treatment of this pig up to the date of drawing the blood for the agglutination test was unusual and undoubtedly influenced the degree of reaction which was very pronounced at 1—1000 and probably would have shown had much higher dilutions and tests been made. The clinical and autopsy records on Expt. 107 have been recorded above. (See page 14.) We can only assume that the feeding of the same culture used in the agglutination tests augmented the agglutinin in the serum of Expt. 107. The only additional tests made with the blood serum of immune pigs not hyperimmunized are recorded in Table III; but, while these tests indicate that the production of agglutinins is increased over those normally present and less than are present in hyperimmunes, they are not comparable with the case of Expt. 107.

VIRUS BLOOD.

Of the virus blood the highest maximum dilution at which agglutination occurred was:

Four cases or 36+% at 1—500.

The lowest maximum dilution at which agglutination occurred was:

One case or 9+% at 1—50.

Three cases or 27+% agglutinated at 1—100.

Three cases or 27+% agglutinated at 1—250.

IMMUNIZING BLOOD.

Of the immunizing blood, the highest maximum dilution at which agglutination occurred was, in four cases or 21+%, 1—2000.

The lowest maximum dilution at which agglutination occurred was:

Six cases 31+% at 1—500.

Nine cases or 47+% agglutinated at 1—1000.

DISCUSSION OF TABLE II.

Suspecting that a reaction would appear at much higher dilutions in many cases, we tested eight samples of blood at a dilution of 1—2000 and recorded a typical and complete reaction in four of these cases. It is apparent that our work is materially weakened by failure to determine the maximum agglutinative power in each case, especially where

a comparison is to be made with the results of tests on different drawings from the same serum hog.

An opportunity was offered to test the agglutinative power of the blood from three different serum hogs at each of three successive bleedings. Serum pig 89 shows a high agglutinative power at the first bleeding, slightly less at the second and apparently greatly increased at the third. Since tests were not made of the first two drawings at dilutions above 1—1000 a careful comparison is impossible. This pig weighed about 110 lbs. at the beginning of the treatment and received over 1200 cc. of virus intramuscularly during a period of about three weeks ending eight days before the first bleeding. After the first bleeding, 350 cc. of virus was injected and after the second bleeding, 200 cc. of virus was injected.

Serum pig 90 showed a slight agglutinative power at the first bleeding, slightly less at the second, and practically the same at the third as at the first. This pig weighed about 110 lbs. at the beginning of the experiment and received about 900 cc. of virus into the muscles, and 100 cc. intravenously during the three weeks ending eight days before the first bleeding. After the first bleeding, 300 cc. of virus was injected and after the second bleeding, 145 cc.

Serum pig 93 showed a weak reaction at 1—500 at each of the first three bleedings. This pig weighed about 100 lbs. at the beginning of the treatment and received 1060 cc. of virus intramuscularly and 340 cc. intravenously during the three weeks preceding the eighth day before the first bleeding. After the first bleeding, 250 cc. of virus was injected and after the second bleeding, 150 cc.

Serum pig 95 could not be bled well from the tail for some undetermined cause, and, after the first attempt, was killed on the following week. A considerable decrease in agglutinative power is noticed from the first to the second bleeding. Only slight differences in agglutinative power are noticed in the two successive bleedings from serum pigs 96 and 97. Serum pigs 117, 118 and 119, show a very great agglutinative power in the one test made in each case.

We find nothing in the treatment of these pigs to suggest an explanation for the difference in agglutinative power of the serum secured at different stages in their treatment. There is, necessarily, an individual variation in pigs that causes them to respond differently to similar or nearly identical treatment, explanations for which fact are not at hand.

For a comparison of the agglutinative power of normal pig's blood and the blood of the pigs tested in Table II we must anticipate the results recorded in Table III, where we find that agglutination does not occur at a dilution even as low as 1—50 when normal defibrinated blood is used in connection with culture "No. 2, Rab. 25."

We find the following comparative results:

Blood of normal pigs, Table III.....	less than 1—50
Blood of immune pigs, Table II.....	1—1000
Blood of virus pigs, Table II.....	1—50 to 1—250
Blood of hyperimmune pigs, Table II.....	1—500 to 1—2000

In the table under each dilution are the signs arranged in two columns to indicate the degree of reaction having reference to the two factors considered above. (See page 7.)

TABLE III.

Showing agglutination tests with Culture "No, 2 Rab. 25" on pigs before and after treatment.

In the table, the sign (+) indicates a complete reaction, the sign (−) indicates that the reaction has progressed considerably., but not completely, and the sign (0) indicates no change.

Source of blood serum tested.	Classification of pigs tested.	Method of securing b ood.	1–50		1–100		1–250		1–500		1–1000		Date blood was drawn.	Date pig died.	Treatment of blood or pig following first bleeding.
			Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.	Agglutination.	Sediment.			
Expt. 211	Normal	Tail	0	0	0	0	0	0	0	0	0	0	5–18–09	.....	Blood defibrinated.
Expt. 212	Normal	Tail	0	0	0	0	0	0	0	0	0	0	5–18–09	.....	Blood defibrinated.
Expt. 213	Normal	Tail	0	0	0	0	0	0	0	0	0	0	5–18–09	.....	Blood defibrinated.
Expt. 214	Normal	Tail	0	0	0	0	0	0	0	0	0	0	5–18–09	.....	Blood defibrinated.
Expt. 215	Normal	Tail	0	0	0	0	0	0	0	0	0	0	5–18–09	.....	Blood defibrinated.
Expt. 216	Normal	Tail	0	0	0	0	0	0	0	0	0	0	5–18–09	.....	Blood defibrinated.
Expt. 211	Normal	Tail	−	−	0	0	0	0	0	0	0	0	5–18–09	.....	Blood coagulated.
Expt. 212	Normal	Tail	−	−	0	0	0	0	0	0	0	0	5–18–09	.....	Blood coagulated.
Expt. 213	Normal	Tail	−	−	0	0	0	0	0	0	0	0	5–18–09	.....	Blood coagulated.
Expt. 214	Normal	Tail	−	−	0	0	0	0	0	0	0	0	5–18–09	.....	Blood coagulated.
Expt. 215	Normal	Tail	−	−	0	0	0	0	0	0	0	0	5–18–09	.....	Blood coagulated.
Expt. 216	Normal	Tail	−	−	0	0	0	0	0	0	0	0	5–18–09	.....	Blood coagulated.
Expt. 211	*Immunized	Tail	−	−	−	−	0	0	0	0	0	0	5–26–09	5–27–09	5 cc. mixed serum 21; 1 cc. virus.
Expt. 212	*Immunized	Tail	+	+	+	+	+	+	+	+	−	−	5–26–09	5–27–09	10 cc. mixed serum 21; 1 cc. virus.
Expt. 213	*Immunized	Tail	+	+	+	+	−	−	−	−	0	0	5–26–09	5–28–09	10 cc. mixed serum 21; 1 cc. virus.
Expt. 214	*Immunized	Tail	+	+	−	−	0	0	0	0	0	0	5–26–09	Alive.....	15 cc. mixed serum 21; 1 cc. virus.
Expt. 215	*Immunized	Tail	+	+	−	−	0	0	0	0	0	0	5–26–09	Alive.....	15 cc. mixed serum 21; 1 cc. virus.
Expt. 216	Virus	At post mortem	+	+	+	+	+	+	+	+	0	0	5–26–09	5–26–09	1 cc. virus.
Expt. 213	Immunized	At post mortem	+	+	+	+	+	+	−	−	0	0	5–28–09	5–28–09	

*These pigs are designated as "immunized" in the sense that they were treated with immunizing serum which was used in insufficient doses in three cases.

SUMMARY OF TABLE III.

A total of 19 tests was made as follows:

Kind of blood tested.	No. of tests.	No. of pigs.
Blood from normal pigs	12	6
Blood from immunized pigs	6	5
Blood from virus pigs	1	1
Total	19	6*

NORMAL BLOOD.

Defibrinated blood serum from six normal pigs or 100% did not agglutinate at 1—50.

Coagulated blood serum from six normal pigs or 100% showed a faint reaction at 1—50.

There is apparently a slightly greater amount of agglutinin in coagulated blood serum than in defibrinated blood serum.

Definite conclusions cannot be drawn from the data at hand.

IMMUNIZED BLOOD.

In order to show the effect of the treatment both as to the amount and nature of the injected material on the production of agglutinin, the immunized pigs are divided into three groups depending upon the dose of serum injected as follows:

(a) The blood of one pig, wt. 15 lbs., receiving 5 cc. of serum, agglutinated at 1—100.

(b) The blood of one pig, wt. 21 lbs., receiving 10 cc. of serum, agglutinated at 1—1000.

The blood of one pig, wt. 26 lbs., receiving 10 cc. of serum, agglutinated at 1—500 upon two different tests.

(c) The blood of two pigs, wt. 24 and 26 lbs., receiving 15 cc. of serum, agglutinated at 1—100.

These results cannot, by themselves, furnish the basis for positive deductions. Until a greater number of tests are made under similar conditions, it is useless to conjecture as to the possible explanations for these results. For the time being, it is sufficient to state that the treatment of the pig both quantitatively and qualitatively influences the production of agglutinin in the blood.

VIRUS BLOOD.

The blood of one virus pig, wt. 26 lbs., agglutinated at a dilution of 1—500. The result in this case is comparable with the reactions noted on virus blood in Table II.

* The six normal pigs furnished the immune and virus blood after being treated.

DISCUSSION OF TABLE III.

That the agglutinative power of pig serum is dependent upon the treatment administered is made manifest in Table III. Six normal pigs from the same litter and subjected to identical environmental conditions showed no agglutinative power for culture "No. 2, Rab. 25" at dilutions of 1—50 when the serum was drawn off from defibrinated blood. Serum secured at the same time from these six pigs but drawn from clotted blood showed a very faint agglutinative power at dilutions 1—50. We have not made a careful or extended study of the influence upon agglutination exerted by different methods of securing and handling the serum.

Within a few hours after drawing the blood from the tails of Expt. pigs 211—216, they were treated as indicated in the table by the serum-simultaneous method, using 1 cc. of virus in each case and from 5 cc to 15 cc. of serum except in the case of Expt. 216, which was left as a check with virus only.

The effect of the treatment upon the agglutinative power of the blood in these six cases is interesting and indicates strongly that there is a close relation between the nature and amounts of the materials used in the treatment to the variations in agglutinative power. Only two of the pigs remained alive and well at the time of this writing. These two, Nos. 214 and 215, received the dose of serum that we have found as a rule necessary to protect pigs of this weight against 1 cc. of virus and subsequent exposure. These two pigs showed an equal increase in agglutinative power toward B. cholerae suis. No. 211, with only one-third the necessary dose of serum to immunize, showed a slight increase in agglutinative power. Nos. 212 and 213, with two-thirds the dose of serum necessary to immunize, showed considerable increase in agglutinative power. The check, No. 216, or virus pig, showed a marked increase in agglutinative power.

We have by no means arrived at that point in our work where we can offer a safe prediction as to what the exact effects will be upon the production of agglutinin as a result of any particular treatment.

GENERAL SUMMARY.

AGGLUTINATION.

The blood serum of normal hogs may agglutinate B. cholerae suis in dilutions as high as 1—125.

The blood serum of virus hogs may agglutinate B. cholerae suis in dilutions as high as 1—700.

The blood serum of immune pigs may agglutinate B. cholerae suis in dilutions as high as 1—1000.

The blood serum of hyperimmune pigs may agglutinate B. cholerae suis in dilutions as high as 1—2000 and possibly higher.

SUSCEPTIBILITY AND IMMUNITY.

Pigs may be killed by injection intravenously or by feeding culture of B. cholerae suis isolated from virus hogs made sick by intramuscular injections of hog cholera blood.

Pigs immunized according to the Turner-Kolle method may withstand intravenous injections of virulent cultures of B. cholerae suis.

CONCLUSION.

It does not seem necessary for us to record the many possible or probable explanations that have occurred to us for the more or less constant results secured in our experiments. To those interested in these problems, there will readily occur equally or more plausible explanations.

We have demonstrated that the hyperimmunization process of Dorset-Niles results in the production of agglutinins and immune bodies for B. cholerae suis. We know neither the nature of these immune bodies nor the constancy with which they occur. It is not determined by our experience whether the production of immune bodies for B. cholerae suis is the only result, i. e., the primary result, of the hyperimmunization process or merely a secondary reaction, incidental to the primary production of immunizing substances against the filterable virus. Our experiments are valuable in paving the way for a clearer understanding of the etiology of hog cholera. Until the etiology of hog cholera is determined by uncontrovertible experimental and clinical evidences, the production of immunity toward hog cholera must remain a matter of uncertainty, constantly subjected to the interrupting influences of unknown factors. If B. cholerae suis is a species distinct from the filterable virus of Dorset and others, then there is truly opened a wonderful field in bacteriology as related to animal pathology, involving the associative action, the symbiotic relations of several pathogens and the common host.

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FOREWORD.

Technical Bulletin No. 4.

For many years past, agricultural chemists have sought some laboratory method by which the fertility of a soil might be determined. As a result, several arbitrary methods have been proposed which, while they give fairly satisfactory evidence upon a few soils, can never be of universal use because of the great variance in soil composition, and also because of the great difference in the feeding powers of different crops. The greater amount of the nitrogen of soils is organic, but as to its form we know practically nothing.

It is our firm belief that before we can intelligently take up the question of how to conserve and make available the plant food already in the soil, we must know more about the nature of the compounds with which we have to deal.

The work undertaken under the subject of this bulletin is such as to frighten only the most intrepid. Nothing could be found in the literature bearing upon the subject and it has been necessary to blaze a trail through an untravelled wilderness.

The results are set forth at this time partly that the data on hand may be more accessible and partly as it marks the termination of the author's connection with this institution.

ANDREW J. PATTEN.

ORGANIC NITROGENOUS COMPOUNDS IN PEAT SOILS.

INTRODUCTION.

Peat deposits must and will of necessity play an important part in the soil economy of the State of Michigan, where not less than one-seventh of the total area consists of swamp lands largely covered by peat and muck. Swamp lands occur also in many other states, especially in New England, in the Northwestern, Western and Middle States, and it is estimated that their entire area in the Union reaches the imposing figure of 75,000,000 acres. These data impress one with the necessity of an investigation of peat soils with a view to learning as much as possible about their agricultural possibilities. The need of such an investigation is quite evident, and in States with extensive peat beds it seems to be imperative. Certainly to the thoughtful observer such research work seems to be indispensable for a good many reasons, and the secrets lying buried in the peat bogs give a mighty impetus to the investigator, as any light shed on the totally unexplored peat deposits in this country promises to be both of interest to science and of practical use to man.

As far as could be learned from the literature within our reach, no systematic investigations of a similar nature have been conducted at all.

When we consider a soil from the standpoint of agricultural chemistry, one of the first things to demand attention is the so-called tripod of agriculture. This is natural enough, since many soils are deficient in one or more of the three elements: potassium, phosphorus and nitrogen, which are absolutely necessary for the growth, development and ripening of plants.

While the chief sources of potassium consist in wood ashes and the German potassium deposits, believed to be practically inexhaustible, the phosphate rocks and bones are the most important sources of phosphorus. There are also rocks containing both potassium and phosphoric acid. The soluble parts of these elements are taken up and assimilated by the plants, which serve as food for the animal organism and finally are again returned to the soil in the form of animal excreta. True, a part of the phosphorus is retained in the animal body to build up the bones, but after the death of the animal these bones are ultimately returned to the soil.

SOURCES OF NITROGEN AND ITS CYCLE.

The conditions are quite different as far as nitrogen is concerned. Though the atmospheric ocean surrounding the earth contains countless millions of tons of nitrogen, it is, as such, of little avail, since the

plants—with the exception of the legumes—are not able to utilize the free nitrogen of the air. It is the combined nitrogen only, that is of agricultural value. While the commercial fertilizing materials, like nitrate of soda found in South America and sulphate of ammonia obtained as a by-product from gas plants and coke ovens, can be readily taken up by plants, the organic nitrogen, whether in the form of commercial fertilizers or of dissociation products from decaying animals and plants, must first, through the action of micro-organisms, be converted into the available forms of ammonia, nitrites and nitrates before it can be assimilated by plants. By the process of assimilation this combined nitrogen is used for building up the proteids, albuminoids, amides, and other complicated organic compounds. As vegetable food these substances are then oxidized in the animal organism, and are eliminated from the system as excreta containing principally urea, uric acid, indole, skatole, keratin, and other nitrogenous compounds. These substances are again gradually converted in the soil into the assimilable nitrates to serve again as food for plants. While the loss of combined nitrogen is inconsiderable through this cycle, there are a number of processes by which the nitrogen is liberated from the nitrogenous compounds and lost as plant food. The fires in woods and fields, whether accidental or intended, the fires kept in our stoves and furnaces, mean an ultimate loss of combined nitrogen contained in the trees, bushes, grasses, lignite, coal, and other combustible materials, since through combustion the nitrogen, as such, is set free. Liberation of free nitrogen occurs under certain conditions as a consequence of a number of other processes: the denitrification through micro-organisms, the reaction of nitrous acid upon organic nitrogenous compounds, the spontaneous decomposition of ammonium nitrite—all these processes[1] liberate more or less free nitrogen. Thus we see that whereas the cycle of potassium and phosphorus causes insignificant losses, which in addition can easily be replaced by the sources at the command of man, the losses incidental to the cycle and to a number of processes in connection with nitrogen are quite considerable. True, there are a few natural processes by which the free nitrogen of the air is fixed. Each thunderstorm fixes a certain amount of air nitrogen, since the electric spark has the power to convert the free nitrogen in the presence of oxygen and moisture—conditions present in the air—into nitric acid. There is also some ammonia in the atmosphere, which with rain, snow, and other atmospheric precipitations, reaches the soil, although the latter process cannot properly be considered a synthetic one, as the ammonia in the air originates principally from the decay of organic nitrogenous substances. But all these processes do not avail much, since the total quantity of combined nitrogen coming to the soil annually in this way is only about four[2] and one-half pounds to at most fourteen[3] pounds of nitrogen per acre. Much larger amounts of atmospheric nitrogen are fixed in the soil through the action of the bacteria associated with leguminous plants. It is also known that some soil bacteria as well as certain forms of fungi have the power of fixing the nitrogen of the air directly.

[1]O. Kellner and T. Yoshii, Zeitschr. f. physiol. Chem. 12, 105-107, (1888).

[2]James Muir, The Utility of Sulphate of Ammonia in Agriculture, p. 7, 1899.

[3]Justus v. Liebig, Die Chemie in ihrer Anwendung auf Agricultur und Physiologie, p. 44, (1876).

As to the amounts of nitrogen added to the soil yearly by these agencies little is definitely known, but it is certain that, today, a much larger amount of nitrogen is removed from the soil by crops than is returned to it by synthetic or other means.

Whether these demands can ever be supplied from the atmospheric nitrogen, by more intelligent farm practices, is a question for the future to answer. However, until that time comes, the constant losses of nitrogen must naturally be supplied by manures and expensive commercial fertilizers, if the fertility of the soil is to be maintained.

In the peat bogs nature has placed at the command of man soils with large quantities of combined nitrogen. From the data given further it will be seen that the different types of Michigan peat contain in round figures from two to two and one-half per cent nitrogen in the air-dried state, and from four-tenths to five-tenths per cent nitrogen when dug from the bog. This percentage means that about four tons of nitrogen (equivalent to twenty-four tons of nitrate of soda) are contained in each acre-foot. Such a quantity of nitrogen, if it could be utilized, would be sufficient for continuous cropping during three-quarters of a century.

OUTLINE OF THE WORK AND GENERAL STUDIES.

The analysis of a brown peat from Chelsea, Michigan, given in the experimental part of this paper, and representing the most abundant type of this state, showed that it contains potash and phosphoric acid in comparatively inconsiderable quantities, whereas the percentage of nitrogen, as already mentioned, is very high. This fact, together with the consideration that nitrogen is the most important and valuable constituent in soils, led us to begin the investigation of the composition of the nitrogenous compounds in peat soils. Such compound may be either of organic or inorganic nature.

While the number of possible inorganic nitrogenous compounds is small—ammonia and its salts, hydrazin, hydroxylamin, hydrazoic acid, nitrous and nitric acid being the most important ones—the substances found in soils usually consist of ammonia, nitrites and nitrates. Now, analyses of different peat soils, typical for the State of Michigan, have shown the absence of nitrites and nitrates, also that the quantity of ammonia present is quite small ranging from a few thousandths to a few hundredths of one per cent. Upon general principles the other nitrogenous substances, obtained with difficulty in chemical laboratories, are not likely to be present in the peat soils, and since the distillation of the fresh peat with magnesium oxide gave only a few thousandths to a few hundredths of one per cent nitrogen calculated as ammonia, the presence of the basic compounds, namely of hydrazin and of hydroxylamin, is practically out of the question. Hence the nitrogen contained in Michigan peat soils practically consists of organic bodies only. But of what nature are they? This question seems to be quite a complicated one when we consider that organic nitrogenous compounds exist in the shape of amines, acid amides, monamino and diamino acids, cyanides, indole derivatives, pyridine derivatives, et cerera, and that the greater part of these bodies can be aliphatic as well as of aromatic origin. In this connection we wish to quote O. Schreiner and E.

C. Shorey, Journal of the American Chemical Society, August, 1908, p. 1296-97.

"The problem of isolating organic substances from soils has been attempted from time to time in the history of agricultural science. Braconnot, Walse, Gyde, and others have attempted to show by chemical means the presence of the toxic substances, and it is largely due to their failure to obtain positive reactions that the matter was dropped for several years. Investigations have been reported from time to time on the isolation of various humus acids, ulmic, geic, crenic, apocrenic, etc., but the composition of the acid isolated has been a most variable one, differing with each investigation and with each method employed, so that it would not be far from the truth to say that none of these acids were shown to exist and that we know almost nothing about their chemical composition or constitution. The work of isolating and studying such compounds is necessarily slow and difficult to accomplish. In the first place the amount may be very small and the composition of the organic matter of the soil is undoubtedly very complex, being made up of large numbers of organic chemical individuals. The absorption of the soil itself for organic substances is very great so that the ordinary solvents, such as water, alcohol, chloroform, etc., take up but very minute amounts of organic materials. Then, too, there is an astounding lack of method for handling problems of this kind, as there is no previous work which can serve in any measure as a guide."

NATURE OF THE NITROGEN IN PEAT SOILS.

Contemplations of a general nature will give us some idea as to the direction in which the problem under consideration can be attacked. It must be borne in mind that peat is a decomposition product of vegetable matter, chiefly of mosses, grasses, rushes, and many aquatic plants, which during generations, ages or centuries have undergone a slow process of degradation. Apart from some mineral constituents like potash, calcium and magnesium taken up by the roots, the plants produce and partly store up carbohydrates such as cellulose and starch, proteids, fatty substances, organic acids, et cetera. The plants usually contain several of these substances, although one of them in a larger measure than the others. It is true that since the carbohydrates, fats and fatty acids consist of carbon, hydrogen and oxygen only, we can eliminate them from further consideration. On the other hand, we have to consider that there are some plants which produce alkaloids in which the binding of the nitrogen in the molecule is quite different from its binding in the proteid molecule, as the alkaloids are closely related to pyridine—their common parent body. But since the bulk of nitrogen in plants is commonly made up of proteids, which are contained in all plants, it is obvious that our attention must be directed first of all to the proteids and their decomposition products. However, in order to get some general conception as to the compounds or groups of bodies that may be present in peat, we must take into consideration the processes which take place in the plants when they cease to live. It is only proteid in a dry state that is of a constant nature, but when subjected in a moist state to the influence of the ubiquitous bacteria it soon begins to decompose. The process of decomposition splits the complicated pro-

teid molecules into a considerable number of products among which we find some with simple molecular constitution, others of a still very complex nature. The following decomposition products of proteids have been discovered and identified by a great number of investigators:

Hydrogen sulphide,[1] methyl mercaptan,[2] carbon dioxide,[1] ammonia,[1] the volatile fatty acids; acetic, butyric, iso-butyric, iso-valeric caproic,[1] further succinic acid,[1] phenylacetic acid,[3] phenyl-propionic acid,[3] p-oxyphenyl-acetic acid,[4] hydro-para-cumaric acid,[5] leucine,[6] tyrosine,[7] amino-valeric acid,[8] indole,[9] skatole,[10] indole acetic acid,[11] indole propionic acid,[12] phenol[13], cresol,[14] putrescine,[15] cadaverine,[15] ptomaines generally, and others.

Partly the same and partly different products are obtained from proteids when decomposed in the laboratory by chemical means, for instance when boiled with hydrochloric acid or sulphuric acid. The decomposition products furnished in this way are as follows:

Hydrogen sulphide,[16] carbon dioxide,[16] ammonia,[16] histidin,[17] arginin,[17] lysin,[17] diamino-acetic acid,[18] glycocoll,[19] alanine,[19] amino-valeric acid,[19] leucine,[16] tyrosine,[16] aspartic acid,[16] glutamic acid,[16] cystine,[20] phenyl-alanine,[19] and pyrrolidine-carboxylic acid,[19] and humin substances.

Since peat has its origin from gradually decayed plants, and as far as nitrogen is concerned, chiefly from decayed proteids, it follows that the series of bodies representing the decomposition products of proteids through the action of micro-organisms is of special interest to us. However, it is not out of the question that we may find compounds present in the peat which are generally associated with decomposition of proteids by mineral acids.

By considering the above two series of decomposition products more closely, we can readily see that the great majority of them belong to two classes of organic compounds, namely to the monamino acids—leucine, tyrosine, amino-valeric acid, aspartic and glutamic acid, etc.—and to the

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[1]Zeitschr. f. physiol. Chem., 22, 514-521. (1896-97.)

[2]Ber. d. deutsch chem. Gesellsch. 12, I. 648; and Zeitschr. f. physiol. Chem., 22. 514-521. (1896-97.)

[3]Ber. d. deutsch. chem. Gesellsch., 12, I. 648; and Zeitschr. f. physiol. Chem., I. 491. (1885.)

[4]E. und H. Salkowski, Ber. d. deutsch. chem. Gesellsch. 12. I. 648.

[5]E. und H. Salkowski, Ber. d. deutsch. chem. Gesellsch. 13. I. 189.

[6]Zeitschr. f. physiol. Chem. 22. 514. (1896-97.)

[7]Zeitschr. f. physiol. Chem. 2.

[8]E. und H. Saldowski, Ber. d. deutsch. chem. Gesellsch. 16. I. 1191.

[9]W. Kühne, Ber. d. deutsch. chem. Gesellsch. 8. I. 206.

[10]M. Nencki, Zeitschr. f. physiol. Chem., 4. 371-372.
Gesellsch. 13, I. 189; and Zeitschr. f. physiol. Chem. 27. 302. (1899); and Ber. d. deutsch. chem. Gesellsch. 37, 1801 (1904).

[12]E. Salkowski, Zeitschr. f. physiol. Chem. 27, 302. (1899); and Ber. d. deutsch. chem. Gesellsch. 38, 2884 (1905).

[13]L. Brieger, Zeitschr. f. physiol. Chem. 3, 137. (1879-80.)

[14]E. Baumann und L. Brieger, Zeitschr. f. physiol. Chem. 3. 149. (1879.)

[15]A. Ellinger, Ber. d. deutsch. chem. Gesellsch. 31. III. 3183.

[16]Hlasiwetz und Habermann, Ann. Chem. Pharm. 169, 150; also, Journal fur praktische Chemie. 2. 7. 397.

[17]E. Schulze und E. Winterstein, Zeitschr. f. physiol. Chem. 28. 459.

[18]Drechsel, Ber. d. k. sachs. Ges. d. Wiss. 44. 115.

[19]Emil Fischer, P. A. Levene und R. H. Aders, Zeitschr. f. physiol. Chem. 35. 70-79. (1902.)

[20]K. A. H. Mörner, Zeitschr. f. physiol. Chem. 28. 595. (1899.)

diamino acids—histidin, arginin, lysin and diamino acetic acid. Of the monamino acids the aspartic and glutamic acid may originate from the amides, asparagine and glutamine, which are, as such, often contained in plants. Thus we logically come to the conclusion that the bulk of the nitrogen in peat may be present in the shape of bodies belonging to the three following classes of nitrogenous compounds: amides, monamino acids and diamino acids.

The method applied for the separation of the organic nitrogenous bodies in peat soils was essentially the one employed in the proteid chemistry with slight modifications. A definite volume, usually 100 c. c., of the sulphuric acid or hydrochloric acid extract of the peat, corresponding to about 0.05 gram nitrogen, was, after cooling, carefully neutralized with cream of magnesia, using a slight excess. The ammonia obtained by distillation was absorbed in a flask containing $^{N}/_{5}$ H_2SO_4. The titration gave then the amount of nitrogen corresponding to the amides present in the peat. In estimating the amides, only magnesium oxide was used for distilling off the ammonia, as recommended by Hausmann, since by distillation with strong bases like barium hydroxide, for instance, not only the ammonia corresponding to the amides is distilled off, but also the NH_2—groups of the amino acids may be attacked. The ammonia contained in the reagents used, namely in the acid, distilled water and magnesia was determined by a "blank" analysis and subtracted from the amount found in the substance.

The residue from distillation with magnesia was dissolved in dilute sulphuric acid so as to have approximately a five per cent acid solution, then phosphotungstic acid solution added in a slight excess and allowed to stand for at least twenty-four hours. The precipitate containing the diamino acids was then filtered out, washed with water containing from two and one-half to five per cent sulphuric and the same amount of phosphotungstic acid. The filtrate, together with the diamino acid precipitate, was transferred to a flask and the nitrogen estimated according to Kjeldahl's method.

The filtrate and washings from the diamino acids, containing the monamino acids, were filled up with distilled water to a definite volume, usually to 500 c. c., of which 100 c. c. or 200 c. c. were oxidized by the Kjeldahl method. In order to avoid violent bumping, because of the presence of phosphotungstic acid, 40 or 50 c. c. of sulphuric acid were used for oxidation, instead of 20 c. c., and the resulting kjeldahlized liquid partly saturated with sodium hydroxide in substance. The amount of ammonia found by distillation and calculated to the total volume gave the percentage of nitrogen corresponding to the monamino acids.

Instead of directly determining the monamino-nitrogen by Kjeldahl's method, which is difficult to accomplish in an exact way, the sum of the percentages of amido-nitrogen and diamino-nitrogen can be subtracted from the total quantity of nitrogen extracted from the peat. The difference evidently represents the monamino-nitrogen.

ANALYTICAL METHODS.

Carbon and hydrogen were determined in the usual way in a combustion furnace.

Nitrogen was estimated by both the absolute method and the Kjeldahl

method. The absolute nitrogen estimation was carried out after Dumas with the modification of Schiff.

Sulphur (total) was estimated by Eschka's method, namely by burning the substance with a mixture of burned magnesia and water-free sodium carbonate. The burned mass was then completly oxidized with the aid of water-free ammonium nitrate (or by bromine water), treated with hot water, when the sulphuric acid in the sulphates obtained was determined in the usual way by precipitating with barium chloride.

The hydrochloric acid extract of the peat was analyzed essentially in accordance with the methods for the analysis of soils, adopted by the Association of Official Agricultural Chemists.

For the ammonia estimation only the fresh peat samples as dug from the bog were used. It was carried out according to Schlösing's method somewhat modified: 50 (or 100) grams of the bog-wet peat were transferred to a flask, then 100 (or 200) c. c. distilled water added, mixed, and strong hydrochloric acid allowed to flow in from a burette until it was in some excess, and the well mixed peat showed a distinctly acid reaction. Now, sufficient distilled water was added to make the total amount of liquid 400 c. c. (or a smaller definite volume) in which the moisture present in the peat—determined in a separate sample—was included. The tightly stoppered flask was now vigorously shaken, allowed to stand for several hours, the supernatant liquid rapidly decanted through a dry filter, and an aliquot part of the filtrate, usually 200 c. c. equal to 50 grams of the peat, taken for distillation. The liquid was neutralized with about 10 grams of magnesium oxide previously converted with 100 c. c. of distilled water into a cream. The method described is preferable to the method of ammonia estimation by directly distilling the soil with magnesium oxide, since in the latter case also some ammonia, that might be split off from the organic nitrogenous substances—e. g. from the amides—would distill over.

The specific gravity of the peat sample was determined by means of a pycnometer.

Whenever only one analysis is given, it is, as a rule, the average of at least two individual analyses.

EXPERIMENTAL PART.

Prior to starting experiments with the object in view of finding out the various organic nitrogenous compounds contained in peat soils, it was thought advisable to establish their composition by elementary analysis. This was also suggested by the fact that the literature, as far as we know, contains very few complete analyses of American peat soils, at least as far as the organic constituents are concerned. Then, too, it was our intention to investigate only those peat types that are rich in nitrogen and at the same time abundant in the State of Michigan. The brown peat sample,[1] the analyses of which are given further, is one that is typical for Michigan. It was taken from three to four feet below the surface or about the usual water line in that peat deposit. It is made up of fibrous remains of sedges and, in the upper layers, of small shrubs

[1]All of the peat samples referred to in this bulletin were very kindly furnished by Dr. Chas. A. Davis of the U. S. Geological Survey.

and similar plants. It represents a well-decomposed, fibrous, brown peat. In order to have the peat sample in a state suitable for analytical purposes, it was dried in an electric drying oven at a temperature of from 40 to 60 degrees Centigrade, and then put through a sieve having 40 meshes to the inch. The lumps were rubbed by means of a rubber-tipped pestle. The amount of matter that did not pass through this sieve was about one and one-half per cent. All the experiments given in this bulletin were made with peat prepared in this manner except in a few cases, where the peat was reduced to a finer state of pulverization. Since peats of different moisture content were used for various analyses and tests, we shall, in order to avoid misunderstandings, make use of the following expressions: Bog-wet peat, meaning a peat with its full water content just as it comes from the bog; air-dry peat, one that was dried at room temperature for about one week; oven-dried peat, one that was dried at a temperature of about 100–105 degrees Centigrade to constant weight; and finally, for the sake of convenience, we shall under "50° dried peat" understand a peat dried in an air-bath at from 40 to 60 degrees C.

ESTIMATION OF CARBON, HYDROGEN AND NITROGEN.

1. 0.6504 grams 50° dried peat gave 1.2440 grams CO_2 equal to 52.16% C. and 0.2892 grams H_2O equal to 4.94% H.

1a 0.6486 grams 50° dried peat gave 1.2430 grs. CO_2 equal to 52.26% C. and 0.2886 gr. H_2O equal to 4.94% H. Average 52.21% C. and4.94% H.

2. 0.9380 grams 50° dried peat on oxidation after Kjeldahl neutralized 8.55 c. c. $^N/_5$ H_2SO_4 equal to 2.56% N.

2a. 1.3337 grams 50° dried peat on oxidation after Kjeldahl neutralized 12.35 c. c. $^N/_5$ H_2SO_4 equal to 2.60% N.

2b. 1.3773 50° dried peat gave 32.6 c.c. N. at 22 degrees C. and 721 mm. bar. pressure equal to 2.54% N.

2c. 1.3781 grams 50° dried peat gave 33.7 c. c. N. at 23 deg. C. and 739 mm. bar. pressure equal to 2.68%N. Average 2.60% N.

ESTIMATION OF SULPHUR, MOISTURE AND ASH.

3. 1.1066 grams 50° dried peat gave 0.02758 gr. $BaSO_4$ equal to 0.003788 gr. S. or 0.34%.

3a. 1.1639 grams 50° dried peat gave 0.02688 gr. $BaSO_4$ equal to 0.003692 gr. S or 0.32%. Average 0.33% S.

4. 3.9330 grams bog-wet peat lost on drying 3.4249 grs. equal to 87.08% water.

4a. 3.5307 grams bog-wet peat lost on drying 3.0813 grs. equal to 87.27% water. Average 87.17% water.

5. 3.0713 grams air-dry peat lost on drying 0.2821 grs. equal to 9.18% water.

5a. 4.3462 grams air-dry peat lost on drying 0.3904 grs. equal to 8.98% water. Average 9.08% water.

6. 5.9242 grams 50° dried peat lost on drying 0.3045 gr. equal to 5.14% water.

6a. 2.3872 grams air-dry peat lost on drying 0.1242 gr. equal to 5.20% water. Average 5.17% water.

7. 3.4497 grams 50° dried peat left on burning 0.2135 gr. equal to 6.19% ash.[1]

7a. 3.0074 grams 50° dried peat left on burning 0.1918 gr. equal to 6.38% ash. Average 6.28% ash.

8. The oven-dried peat was found to have 1.5231 sp. gr.

8a. The oven-dried peat was found to have 1.4818 sp. gr.

8b. The oven-dried peat was found to have 1.5077 sp. gr. Average 1.5042 sp. gr.

Calculated to water-free basis we get the following figures:

(1, 1a). Carbon	55.06%
(1, 1a). Hydrogen	5.21%
(2, 2a, 2b, 2c). Nitrogen	2.74%
(3, 3a). Sulphur	0.35%
(7, 7a). Ash	6.62%
Oxygen	30.02%

EXTRACTION OF THE NITROGENOUS BODIES FROM PEAT SOILS.

In order to be able to separate the nitrogenous bodies present in peat soils, it was necessary, first of all, to find a suitable solvent for the extraction of these compounds. It was soon found that the quantity of nitrogenous substances which could be extracted with water was very small. Neither ammonia nor a fixed alkali could be used for the extraction, since the first reagent contains nitrogen, and the application of the other could cause some loss of nitrogen from the peat, in the form of ammonia. After a few preliminary tests it was established that moderately dilute sulphuric and hydrochloric acids are the most suitable solvents for the purpose we had in view. Since only a small part of the peat soils could be dissolved in these acids, the suggestion was plausible that a number of factors, like the amount and concentration of the acids, temperature and duration of digestion, as well as the fineness of the samples, might have an influence upon the percentage of nitrogenous bodies that could be extracted. The experiments, the results of which are contained in Table No. 1, have fully confirmed this supposition. Before presenting the results, however, we shall briefly describe the manner in which the peat was extracted with the various reagents: A definite amount of peat—ranging from 5 to 30 grams—was transferred to a 500 or 1,000 c.c. flask, and distilled water and varying strengths of sulphuric or hydrochloric acid added, the quantity of acid varying in round numbers from 20 to 90 times the amount of peat to be extracted. The contents of the flask were shaken to a uniform mass, heated to the boiling point and kept boiling under a reflux condenser for a certain number of hours. Or, instead of boiling with a reflux condenser, the flask containing the peat with the reagents was put into an autoclave where it was kept under a constant pressure. The boiled mass was then somewhat diluted with distilled water, filtered, and washed with boiling water. The peat remaining on the filter was then transferred to a flask

[1] A qualitative examination of the ash showed the presence of the following substances: Phosphoric acid, iron, aluminum, sulphur, calcium, magnesium, potassium and sodium.

of two liters capacity, about one liter of distilled water added, boiled for a few minutes, siphoned off, washed with hot water, and these operations repeated again. The filtrate and washings were evaporated and filled up to a definite volume, usually to 500 or 1,000 c.c., of which 100 or 200 c.c. were taken for nitrogen determinations by the Kjeldahl method. The nitrogen found was calculated to the original volume. Results of this experiment will be found in Table No. 1 under method A.

Since the repeated boiling and washing with hot water, as well as the filtrations, require considerable time, this method was modified in a number of cases as follows: After digestion of the peat for a specified length of time, either under a reflux condenser or in the autoclave, the flask content was cooled to room temperature and filled up to a definite volume with distilled water. After shaking, it was filtered through a dry filter, and two portions of the filtrate—each containing 50 or 100 c. c.—were taken for nitrogen estimations by Kjeldahl's method. The nitrogen thus found was calculated to the actual volume of the liquid minus the volume occupied by the peat. The results of this experiment will be found in Table No. 1 under method B. That these two methods differ to a certain degree in their results may be partly due to the high absorptive power of peat for ammonia and other nitrogenous substances.

TABLE NO. 1.

Quantity of nitrogen extracted from peat under various conditions.

Number of experiment.	Grams of oven-dried peat.	Reagent used.			Ratio of wt. of reagent to wt. of oven-dried peat.	Hours digested.	Mode of digestion.	Nitrogen extracted.			
		H_2SO_4 grams.	H_2O grams.	Strength of acid. (Per cent. by wt.)				Method B. Per cent. of total N in peat.	Method A.		
									Grams.	Per cent. of total N in peat.	Per cent. of oven-dried peat.
1	4.7415	60.8	118.0	33.3	38	28	Boiling under reflux condenser	50.47	0.06605	50.84	1.39
2	4.7415	60.8	118.0	33.3	38	10	" "	43.09	0.05616	43.23	1.19
3	4.7415	85.5	337.0	20.0	90	28	" "	39.22	0.06171	47.50	1.30
4	4.7415	142.5	150.0	47.5	63	28	" "	55.41	0.07750	59.65	1.63
5	4.7415	121.6	236.0	33.3	77	25	Treated in autoclave	51.12	.....	.....	.....
6	9.4830	128.3	250.0	33.3	41	32	½ atm. pressure	.....	0.14545	55.98	1.53
7	9.4830	128.3	250.0	33.3	41	35	Boiling under reflux condenser	.....	0.14690	56.54	1.55
8	9.4830	285.0	300.0	47.5	63	30	" "	.....	0.16090	61.92	1.70
9	28.449	286.9	300.0	47.5	21	72	" "	.....	0.49842	63.94	1.75
10	28.449	.....	300.0	.....	11	16	" "	3.73	.....	.....	.....
11	28.449	.....	500.0	.....	18	10	Treated in autoclave ½ atm. pressure	5.77	.....	.....	.....
12	28.002[1]	199.5	388.0	33.3	21	60	Boiling under reflux condenser	.....	0.34601	58.56	1.24
13	28.002[2]	199.5 H Cl	388.0	33.3	21	60	" "	.....	0.35928	60.81	1.28
14	9.4830	136.2	222.3	38.0	38	30	" "	.....	0.14549	55.99	1.53

[1]For this experiment a black peat was used, the analysis of which is given on page 25. It passed through a 20 mesh sieve.
[2]Black peat passed through an 80 mesh sieve.

In glancing at the table, one can see at once that the concentration of the acid and the duration of digestion have the greatest influence, whereas the quantity of the reagents used has only a slight influence upon the percentage of nitrogenous bodies that can be extracted from the peat. Thus, comparing the experiments 1 and 2, 4 and 8, 6 and 7 where, with the exception of the time of digestion, all the conditions were the same, we find that the percentage of nitrogenous substances extracted rises with increased hours of digestion. Also we notice, by comparing the experiments 3 and 4 having equal hours of digestion, that, although in the latter the amount of acid used is considerably smaller than in 3, yet the percentage of extracted nitrogen is about 12 per cent higher, showing the predominating influence of the concentration of the sulphuric acid. The same conclusion can be drawn from experiments 1 and 3. What is true of the sulphuric acid is also true of the hydrochloric acid, which extracts about the same percentage of nitrogen as does the sulphuric acid under equal conditions. Thus the experiments 4, 8 and 14, with the same or about the same hours of digestion, show that the 47 per cent sulphuric acid extracted more nitrogen than the 38 per cent hydrochloric acid, whereas from the experiments 1 and 14 it follows that the hydrochloric acid of a higher concentration was able to extract more nitrogen than the sulphuric acid of a lower concentration.

The experiments 10 and 11 show how small an amount of nitrogenous bodies can be extracted from the brown peat by means of water. This also holds true for other types of peat, for instance, for black peat as well as for weathered brown peat, of which more will be said in the following pages.

That from a peat in a finer state of division more nitrogen can be extracted than from a coarser peat is plainly seen from experiments 12 and 13, conducted under exactly the same conditions with the exception of the fineness to which the respective peat samples were reduced. From this it follows further that the percentages of nitrogen extracted from the brown peat and given in Table No. 1 should be considered as minimum figures, since all the experiments, with the exception of 13, were made with peat which passed a 20 mesh sieve.

But on the other hand, even boiling for several days with quite strong acid did not dissolve out all the nitrogen contained in the peat. Since the separation of different organic nitrogenous bodies into groups can be accomplished only in an acid solution, the question as to whether it is possible to extract all the nitrogen from peat by means of acids was of considerable importance. To definitely decide this question a few peat samples were boiled for a number of hours with fairly strong acid, filtered and thoroughly washed with hot water. The peat was re-extracted several times, being thoroughly washed with hot water after each extraction. The filtrates and washings from each digestion were filled up to a definite volume and the nitrogen estimated according to Kjeldahl's method. Table No. 2 contains the results obtained through repeated digestions.

TABLE NO. 2.

Nitrogen extracted from peat by repeated digestion with acid.

Number of experiment.	Digestion.	Amount of oven-dried peat used for extraction; grams.	Strength of H_2SO_4 used for extraction; (per cent. by weight.)	Hours digested.	Mode of digestion.	Nitrogen extracted.		
						Grams.	Per cent. of total nitrogen.	Per cent. of oven-dried peat.
1	1st	4.7415	33.3	10	Boiling under reflux condenser	0.05616	43.23	1.19
"	2nd	.....	33.3	11	" "	0.01300	10.01	0.27
"	3rd	.....	33.3	29	" "	0.01248	9.61	0.26
"	4th	.....	33.3	32	" "	0.00710	5.47	0.15
					Total.....	68.32		1.87
2	1st	7.5864	25.4	10	" "	0.09507	45.74	1.25
"	2nd	.....	33.3	15	" "	0.01803	8.67	0.24
"	3rd	.....	25.0	22	" "	0.01184	5.70	0.16
					Total.....	60.11		1.65
3	1st	4.7415	33.3	28	" "	0.06605	50.84	1.39
"	2nd	.....	33.3	29	" "	0.01360	10.47	0.29
"	3rd	.....	29.1	42	" "	0.00842	6.48	0.18
					Total.....	67.79		1.86
4	1st	9.4830	33.3	32	" "	0.14545	55.98	1.53
"	2nd	.....	33.3	49	" "	0.01155	4.45	0.12
					Total.....	60.43		1.65

In viewing the results of Table No. 2 we can readily see that the total amount of nitrogen extractable from peat can be increased a few per cent by repeated digestion, although even in the latter case it was not possible to obtain all the nitrogen in solution, 68.32 being the highest percentage of nitrogen extracted with acid. However, taking into consideration the experiments 12 and 13 of Table No. 1 as well as experiment 1 of Table 2, we are justified in stating that at least 70% of nitrogen can be obtained in solution if the digestion with acid is performed with a brown peat that has passed through an 80 mesh sieve. But the question as to whether it is possible to extract all the nitrogenous bodies from peat by digesting with acid must be answered in the negative, at least this is true under the conditions given in the Tables Nos. 1 and 2. It is possible that the part of nitrogen which cannot be obtained in acid solution is of humin nature.

SEPARATION OF THE ORGANIC NITROGENOUS BODIES INTO DIFFERENT GROUPS.

As already mentioned, practically all the nitrogen contained in the brown peat is of organic nature. Neither nitric nor nitrous acid is present in the peat. This was confirmed by qualitative experiments.

Concerning the ammonia present as such in the peat, it must be remembered that it is also represented in the total amount of ammonia obtained by distilling the acid-treated peat with magnesium oxide. Hence, we must subtract the ammonia present as such in the fresh peat from this total amount of ammonia in order to find the ammonia corresponding to the amides only. Table No. 3 shows the percentage of the different nitrogenous groups contained in the brown peat.

TABLE NO. 3.

Amount and percentage of nitrogen contained in the different groups in brown peat.

Number of experiment.	Used for experiment.		Strength of sulphuric acid used for extraction, (per cent. by weight.)	Nitrogen obtained in solution.			Ammoniacal nitrogen originally contained in peat.			Organic Nitrogen.								
										Amido-Nitrogen.			Diamino-Nitrogen.			Monamino Nitrogen.		
	Oven-dried peat, grams.	Total nitrogen in peat, grams.		Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.
1	9.483	0.25983	33.3	0.14545	55.98	1.53	0.00417	1.60	0.044	0.03570	13.74	0.376	0.00814	3.13	0.086	0.09744	37.51	1.03
2	9.483	0.25983	33.3	0.1469	56.54	1.55	0.00360	1.39	0.038	0.03627	13.95	0.382	0.00828	3.19	0.087	0.09875	38.01	1.04
3	9.483	0.25983	47.5	0.16020	61.65	1.69	0.00360	1.39	0.038	0.04694	18.06	0.495	0.00543	2.09	0.057	0.10423	40.11	1.10
4	28.449	0.77950	47.5	0.49842	63.94	1.75	0.01252	1.61	0.044	0.14278	18.32	0.502	0.02681	3.44	0.094	0.31631	40.57	1.11
Av'ge.	.....	.....	.....	.....	59.53	1.63	.....	1.50	0.041	.....	16.02	0.439	.....	2.96	0.081	.....	39.05	1.07

From the above table it can readily be seen that the strong acid (47.5%) gave about six per cent more nitrogen in solution than the weaker acid and that this nitrogen was chiefly amido-nitrogen, and monamino-nitrogen. When we consider the nitrogen in solution as 100 and reduce to this basis the data given in Table No. 3, we get the figures contained in the table below:

TABLE NO. 4.

Number of experiment.	Ammoniacal Nitrogen originally contained in peat.	Amido-Nitrogen.	Diamino-Nitrogen.	Monamino-Nitrogen.	Total nitrogen in solution.
	Per cent. of nitrogen in solution.				
1	2.87	24.54	5.59	67.00	100.00
2	2.45	24.69	5.64	67.22	100.00
3	2.24	29.31	3.39	65.06	100.00
4	2.51	28.65	5.38	63.46	100.00
Average	2.52	26.80	5.00	65.68	100.00

The percentage of monamino-nitrogen given in this table was found by difference from hundred. This percentage was usually higher than the one directly found by kjeldahlizing the filtrate from the phosphotungstic acid precipitate. For instance, in experiment 2 the percentage of monamino-nitrogen directly found was only 62.83 and in experiment 3 it was 64.25 per cent instead of 67.22 and 65.06 respectively. The chief reason why the direct determination usually gives too low a percentage of the monamino acids lies in the difficulty of a complete oxidation of the nitrogenous bodies in the presence of an excess of phosphotungstic acid.

An attempt was made to isolate in substance and, if possible, to identify the diamino and monamino acids present in the peat. For this purpose a brown peat from Chelsea, Michigan, was used of the same type as the one previously described. The hydrochloric acid extraction of this second peat sample showed the following composition:

Silica (SiO_2)	0.044 per cent.
Ferric Oxide (F_2O_3)	0.107 per cent.
Aluminic Oxide ($A1_2O_3$)	0.504 per cent.
Lime (CaO)	0.078 per cent.
Magnesium Oxide (MgO)	0.018 per cent.
Potassium Oxide (K_2O)	0.107 per cent.
Sodium Oxide (Na_2O)	0.074 per cent.
Phosphorus Pentoxide (P_2O_5)	0.099 per cent.
Sulphuric Anhydride (SO_3)	0.150 per cent.

Several determinations of the nitrogen content of the oven-dried peat gave the following figures:

(a). 2.28% nitrogen, by Kjeldahl's method.
(b). 2.36% nitrogen, by Kjeldahl's method.
(c). 2.17% nitrogen, by Kjeldahl's method.
(d). 2.14% nitrogen, by Kjeldahl's method.
(e). 2.27% nitrogen, by Kjeldahl's method.
Mean 2.24% nitrogen, by Kjeldahl's method.
(f). 2.21% nitrogen, by Kjeldahl's method, modified for nitrates.
(g). 2.21% nitrogen by the absolute method.
(h). 2.36% nitrogen by the absolute method.
Mean 2.26% nitrogen by the absolute method.

This second brown peat sample, like the first one, does not contain any nitric acid. This was confirmed by qualitative tests.

The carbon and hydrogen determination showed that the peat contains 60.03 per cent carbon and 5.73 per cent hydrogen, calculated upon peat free from water and ash.

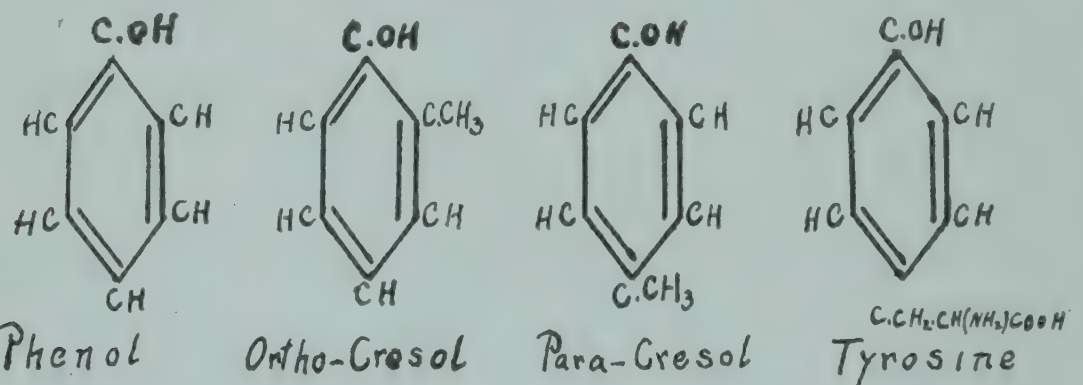
With the brown peat of this composition the following experiments were made:

To 54.94 grams of air-dried peat corresponding to 50 grams of oven-dried peat, a mixture of 150 grams conc. H_2SO_4 and 300 grams of water was added heated to the boiling point, and kept boiling under reflux condenser for 14 hours. During the boiling, development of hydrogen sulphide was noticed. (H_2S could also be detected when another sample of peat was digested with hydrochloric acid). The flask content was filtered, the peat remaining on the filter was transferred to a flask, boiled with water, filtered and washed with hot water. These operations were repeated three times. The filtrate and washings were evaporated, filled up to 1000 c.c., and two Kjeldahl determinations made to determine the amount of extractable nitrogenous bodies. The peat extract was then treated with a hot solution of $Ba(OH)_2$ in order to remove nearly all the sulphuric acid. The barium sulphate was filtered out, boiled with water three times, and each time siphoned off and thoroughly washed. The filtrate and washings were somewhat concentrated and then treated with magnesium oxide on a water bath until all ammonia was removed. Barium hydroxide solution was then added in excess, the precipitate, consisting chiefly of magnesium hydroxide and barium sulphate, was filtered out, and then extracted three times with hot water. The filtrate and washings were united and sulphuric acid added in some excess to remove the baryta. This solution containing the organic nitrogenous bodies was treated according to the method given by A. Kossel for the separation and identification of histidin and arginin as silver compounds. The result was a negative one.

The resulting filtrate from the above procedure was acidulated with sulphuric acid and treated with H_2S. The new precipitate consisting of $BaSO_4$ and Ag_2S was filtered out, extracted with hot water, the filtrate and washings were somewhat concentrated and H_2SO_4 was added so as to make the solution contain 5 per cent. It was then treated with phosphotungstic acid. A precipitate was obtained which was washed with

a five per cent sulphuric acid and then treated with barium hydroxide to remove the phosphotungstic acid. The filtrate was freed from barium by means of CO_2, evaporated nearly to dryness, taken up with hot water and filtered. The filtrate, when evaporated nearly to dryness, consisted of a few drops of a brown syrup. This, treated with picric acid, gave a yellow precipitate too small in quantity for its identification.

The filtrate from the phosphotungstic acid precipitate, supposed to contain monamino acids, was treated with barium hydroxide to remove the phosphotungstic acid and then treated with CO_2 to remove excess of baryta. The filtrate from $BaCO_3$ showed the Millon reaction. This suggested tyrosine. On the other hand, it must be taken into consideration that nearly all benzol derivatives in which one H-atom is replaced by the OH-group give the same reaction. Considering the relation of peat to protein decomposition products, the following compounds were probable.



On adding iron chloride solution to the filtrate from $BaCO_3$, no violet or blue color reaction was noticed. Addition of bromine water did not cause any precipitate. These two negative reactions showed that the filtrate under consideration did not contain either phenol or cresol. The non-volatility of the substance in question suggested the presence of tyrosine. However, identification of the tyrosine by means of the microscope or Piria's test could not be accomplished, since the tyrosine was not obtained in substance. This will be comprehended when we recall that altogether only 0.43 gram of nitrogen was originally in the form of organic compounds a part of which was lost through a number of the operations mentioned above, and that the remaining nitrogen was very likely present in the shape of various monamino acids.

WEATHERED BROWN PEAT.

It was of interest to learn whether the peat undergoes changes, and if so of what nature, when subjected to atmospheric influences. For this purpose a sample of brown peat was taken which has been weathering for two or three years on the surface of the bog. In the following are given the analyses showing the composition of the weathered peat.

DETERMINATION OF CARBON, HYDROGEN AND NITROGEN.

1. 0.3979 grams 50° dried peat gave 0.7586 gr. CO_2 equal to 52.00% C. and 0.1897 gr. H_2O equal to 5.30% H.

1a. 0.3637 grams 50° dried peat gave 0.6974 grams CO_2 equal to 52.30% C. and 0.1760 gr. H_2O equal to 5.38% H. Average 52.15% C. and 5.34% H.

2. 0.9852 grams 50° dried peat on oxidation after Kjeldahl neutralized 9.15 c. c. $^N/_5$ H_2SO_4 equal to 2.61% N.

2a. 0.9229 gram 50° dried peat on oxidation after Kjeldahl neutralized 8.35 c. c. $^N/_5$ H_2SO_4 equal to 2.54% N.

2b. .04720 grams 50° dried peat gave 10.9 c. c. N at 19 deg. C. and 742 m. m. bar. pressure equal to 2.59% N. Average 2.58% N.

DETERMINATION OF SULPHUR, MOISTURE AND ASH.

3. 0.9538 gram 50° dried peat gave 0.0227 gr. $BaSO_4$ equal to 0.0031 gr. S. or 0.33%.

3a. 0.7122 grams 50° dried peat gave 0.0165 gr. $BaSO_4$ equal to 0.0023 gr. S. or .32%. Average 0.33% Sulphur.

4. 4.9332 grams bog-weathered peat lost on drying 3.0305 grs. equal to 61.43% water.

4a. 1.9852 grams bog-weathered peat lost on drying 1.2124 grs. equal to 61.07% water. Average 61.25% water.

5. 2.8871 grams 50° dried peat lost on drying 0.1215 gr. equal to 4.21% water.

5a. 5.1132 grams 50° dried peat lost on drying 0.1977 gr. equal to 3.87% water. Average 4.04% water.

6. 1.3602 grams 50° dried peat left on burning 0.0495 gr. equal to 3.64% ash.

6a. 2.1571 grams 50° dried peat left on burning 0.0786 gr. equal to 3.64%. Average 3.64% ash.

7. The oven-dried peat was found to have 1.4338 sp. gr.

7a. The oven-dried peat was found to have 1.4459 sp. gr. Average 1.4398 sp. gr.

Reducing the above analytical data to the dry basis we get the following figures:

(1, 1a). Carbon	54.35%
(1, 1a). Hydrogen	5.56%
(2, 2a, 2b). Nitrogen	2.69%
(3, 3a). Sulphur	0.34%
(6, 6a). Ash	3.79%
Oxygen. (Difference from 100)	33.27%

The peat showing the above analysis was separated into different nitrogenous groups. The results are given in the table below:

TABLE NO. 5.

Amount and percentage of nitrogen contained in the different groups in weathered brown peat.

Number of experiment.	Used for experiment.		Strength of acid used for extraction, (per cent. by weight).	Nitrogen obtained in solution.			Ammoniacal nitrogen originally contained in peat.			Organic Nitrogen.								
										Amido-Nitrogen.			Diamino-Nitrogen.			Monamino-Nitrogen.		
	Oven-dried peat, grams.	Total nitrogen in peat, grams.		Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.
			H_2SO_4															
1	9.596	0.25813	33.3	0.15735	60.96	1.64	0.00048	0.186	0.005	0.03773	14.62	0.393	0.0	0.0	0.0	0.11914	46.15	1.24
2	9.596	0.25813	H Cl 38.0	0.17394	67.38	1.81	0.00048	0.186	0.005	0.04058	15.72	0.423	0.0	0.0	0.0	0.13288	51.48	1.38
Av'ge.	.....	.....	.....	.....	64.17	1.72	.....	0.186	0.005	.....	15.17	0.408	.....	0.0	0.0	.....	48.81	1.31

By calculating the data in Table No. 5 to the nitrogen in solution as basis we get the following table:

TABLE NO. 6.

Number of experiment.	Ammoniacal Nitrogen originally contained in peat.	Amido-Nitrogen.	Diamino Nitrogen.	Monamino Nitrogen.	Total nitrogen in solution.
	Per cent. of nitrogen in solution.				
1	0.30	23.99	0.0	75.71	100.00
2	0.28	23.33	0.0	76.39	100.00
Average	0.29	23.66	0.0	76.05	100.00

When we compare the Tables Nos. 5 and 6 with the Tables Nos. 3 and 4, we can readily see that certain changes took place in the nitrogenous groups by virtue of the agencies active in the weathering process. In the first place we notice that whereas in the brown peat, prior to the weathering process, the percentage of ammoniacal and amido-nitrogen was 0.041 and 0.439, it changed to 0.005 and 0.408 respectively in the weathered peat. Thus, through the weathering a total decrease of 0.067 per cent of ammoniacal and amido-nitrogen (calculated on the oven-dried peat) took place, through leaching or some other cause. This may account for the fact that the total nitrogen in the weathered peat is somewhat diminished, being 2.69 per cent in the oven-dried weathered peat, and 2.74 per cent in the oven-dried brown peat before the weathering process. When we express the same figures in percentage of nitrogen in solution, as shown in the Tables Nos. 4 and 6, we see that while the brown peat had 2.52% of ammoniacal and 26.80% of amido-nitrogen, the weathered brown peat had 0.29% and 23.66% respectively, or a total decrease of 5.37%. This, as well as the disappearance of the diamino-nitrogen in the weathered peat, must have necessarily increased the percentage of monamino acids in the weathered peat. It should, however, be borne in mind that, while the estimations of ammoniacal and amido-nitrogen give accurate results, the determination of diamino-nitrogen is not quite satisfactory. This influences, of course, the monamino-nitrogen, since the latter is calculated by difference.

Considering the changes in the weathered peat, the assumption was justified that the solubility of the nitrogenous substances in the peat must have changed. From Table No. 1 it was evident that the solubility in water of the nitrogenous bodies contained in the brown peat is very small. It was of interest to learn the solubility in water of the weathered brown peat. For this purpose a few grams of peat were transferred to a flask, a definite amount of water added, mixed, digested, then filled up, usually, to 500 c.c., mixed, filtered through a dry filter, and two portions of 200 c.c. each taken for kjeldahlization. The nitrogen thus found was recalculated to the total volume. Table No. 7 shows the results of these experiments.

TABLE NO. 7.

The solubility in water of the nitrogenous bodies in weathered brown peat.

Number of experiment.	Used for experiment.		Hours digested.	Mode of digestion.	Nitrogen extracted.		
	Grams oven-dried peat.	Grams distilled water.			Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.
1.....	4.798	400.0	10	Steam autoclave at $\frac{3}{4}$ to $\frac{7}{8}$ atm. pressure.	0.01172	9.08	0.25
2.....	2.8788	300.0	16	Boiling under reflux condenser.	0.00685	8.85	0.24
3.....	4.798	500.0	60	Shaken (10 minutes each hour) at room temperature	0.00300	2.32	0.06

From these experiments it follows that the solubility in water of the nitrogenous compounds in the weathered brown peat increases with the rise of temperature. This was also the case with the brown peat as dug from the bog, as can be seen from experiments 10 and 11 in Table No. 1, and holds true also for the black peat, as shown in Table No. 10. In other words, the solubility in water of the nitrogenous compounds in the various types of Michigan peat is within certain limits, a function of the temperature. This being the case, we can further assume that the peats digested at higher temperature and pressure in a suitable autoclave, will give a larger amount of water-soluble compounds than was obtained, for instance, in experiment 1, Table No. 7. That digestion at a higher temperature gives a higher percentage of water-soluble nitrogenous compounds, is very likely due, partly to hydrolysis of the nitrogenous bodies present in the peat.

When we further compare experiments 10 and 11 in Table No. 1 with the experiments in Table No. 7, we come to the conclusion that, through the natural process of weathering, the amount of water-soluble nitrogenous compounds has somewhat increased. This is of some significance, since the water-solubility is the very first and most essential property of a nitrogenous substance to be available as plant food. However, recalling that only about ten per cent of the nitrogen in acid solution (and still less of the total nitrogen in the peat) has changed through weathering during two or three years, and that, in addition, the changes of the nitrogenous bodies did not go far enough to be converted, for instance, into ammoniacal nitrogen, we come to the conclusion that weathering changes the nitrogenous bodies in the brown peat very slowly.

BLACK PEAT.

The black peat represents another type of peat soils frequently occurring in Michigan. For the experiments a peat sample was taken from about two feet below the surface of the swamp. This peat, being a good example of the black type of peat, had some well rotted wood in it. It represents a more advanced stage than the brown peat from Chelsea.

The composition of the black peat can be seen from the analysis given below.

DETERMINATION OF CARBON, HYDROGEN AND NITROGEN.

1. 1.1105 grams 50° dried peat gave 1.4219 grs. CO_2 equal to 34.92% C. and 0.32944 grs. H_2O equal to 3.30% H.

1a. 0.7172 gram 50° dried peat gave 0.9115 gr. CO_2 equal to 34.67% C. and 0.2112 gr. H_2O equal to 3.27% H.

1b. 0.8400 gram 50° dried peat gave 1.0696 grs. CO_2 equal to 34.72% C. and 0.2553 gr. H_2O equal to 3.38% H. Average 34.77% C. and 3.32% H.

2. 1.0353 grams 50° dried peat on oxidation after Kjeldahl neutralized 7.1 c. c. $^N/_5$ H_2SO_4 equal to 1.93% N.

2a. 1.5735 grams 50° dried peat on oxidation after Kjeldahl neutralized 11.1 c. c. $^N/_5$ H_2SO_4 equal to 1.98% N.

2b. 1.3037 grams 50° dried peat on oxidation after Kjeldahl neutralized 9.25 c. c. $^N/_5$ H_2SO_4 equal to 1.99% N.

2c. 1.0933 grams 50° dried peat gave 19.5 c.c. N. at 25 deg. C. and 742 m. m. bar. pressure equal to 1.94% N.

2d. 1.1001 grams 50° dried peat gave 20.5 c. c. N. at 25 deg. C. and 742 m. m. bar. pressure equal to 2.03% N. Average 1.97% N.

DETERMINATION OF SULPHUR, MOISTURE AND ASH.

3. 0.7634 gram 50° dried peat gave 0.0557 gr. $BaSO_4$ equal to 0.0076 gr. S. or 1.00%.

4. 11.5574 grams bog-wet peat lost on drying 8.2994 grs. equal to 71.81% water.

4a. 7.4938 grams bog-wet peat lost on drying 5.4696 grs. equal to 72.99% water.

4b. 4.8862 grams bog-wet peat lost on drying 3.5371 grs. equal to 72.39% water. Average 72.40% water.

5. 6.2583 grams 50° dried peat lost on drying 0.4226 gr. equal to 6.75% water.

5a. 10.1277 grams 50° dried peat lost on drying 0.6654 gr. equal to 6.57% water. Average 6.66% water.

6. 2.8791 grams 50° dried peat left on burning 1.0054 gr. equal to 34.92% ash.

6a. 2.2067 grams 50° dried peat left on burning 0.7713 gr. equal to 34.95% ash. Average 34.93% ash.

7. The oven-dried peat was found to have 1.7969 sp. gr.

7a. The oven-dried peat was found to have 1.7710 sp. gr. Average 1.7840 sp. gr.

Recalculating upon a water-free basis we find the following figures:

(1, 1a, 1b). Carbon	37.25%
(1, 1a, 1b). Hydrogen	3.55%
(2, 2a, 2b, 2c, 2d). Nitrogen	2.11%
(3). Sulphur	1.07%
(6, 6a) Ash	37.42%

The peat of the above composition was separated into different nitrogenous groups and the results appear in Table No. 8.

TABLE NO. 8.

Amount and percentage of nitrogen contained in the different groups in black peat.

Number of experiment.	Used for experiment.		Strength of H_2SO_4 used for extraction, (per cent. by weight.)	Nitrogen obtained in solution.			Ammoniacal nitrogen originally contained in peat.			Organic Nitrogen.					
										Amido-Nitrogen.			Monamino-Nitrogen.		
	Oven-dried peat, grams.	Total nitrogen in peat, grams.		Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.	Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.
1	28.002	0.59084	33.3	0.34602	58.56	1.24	0.00056	0.095	0.002	0.09129	15.45	0.326	0.25417	43.02	0.91
2	28.002	0.59084	33.3	0.35928	60.81	1.28	0.00056	0.095	0.002	0.09184	15.54	0.328	0.26688	45.17	0.95
Average	.....	.....	.....	.....	59.68	1.26	.....	0.095	0.002	.....	15.50	0.327	.....	44.09	0.93

Recalculating the data in table No. 8 to the nitrogen in solution as basis, we get the following table:

TABLE NO. 9.

Number of experiment.	Ammoniacal nitrogen originally contained in the peat.	Amido-nitrogen.	Monamino-nitrogen.	Total nitrogen in solution.
	Per cent of nitrogen in solution.			
1	0.16	26.38	73.46	100.00
2	0.16	25.56	74.28	100.00
Averages	0.16	25.97	73.87	100.00

The solubility in water of the nitrogenous bodies in the black peat was determined, with the results given in the table below:

TABLE NO. 10.

The solubility in water of the nitrogenous bodies in black peat.

Number of experiment.	Used for experiment.		Hours digested.	Mode of digestion.	Nitrogen extracted.		
	Grams oven-dried peat.	Grams distilled water.			Grams.	Per cent. of total nitrogen in peat.	Per cent. of oven-dried peat.
1	28.002	500	16	Boiling under reflux condenser.	0.02543	4.30	0.09
2	28.002	500	10	In autoclave at $\frac{1}{4}$ to $\frac{1}{2}$ atm. pressure.	0.03804	6.44	0.14

Thus we see from the Table No. 10 that although the peat in experiment 2 was digested during a smaller number of hours, the percentage of nitrogen was larger on account of the higher temperature applied during the digestion. Unfortunately we did not have a high pressure autoclave at our disposal. The solubility in water of the nitrogenous bodies in peats at higher temperatures will be taken up later.

CONCLUSIONS.

While the data in hand do not warrant conclusive deductions as to the agricultural value of peat soils, for which further investigation will be necessary, the results obtained and given in this bulletin permit of drawing the following conclusions:

1. There are no nitrates in the different types of Michigan peat soils examined.

2. The amount of ammonia is small, ranging from a few thousandths to a few hundredths of one per cent, thus representing the nitrogen immediately available as plant food. In the case of the brown peat, the amount of ammonia is sufficient to meet the needs of one or two crops as is evident from the following: There are in an acre-foot in round numbers 170 tons of oven-dried peat, with 0.041% ammoniacal nitrogen, making 0.0697 tons or 139.4 pounds nitrogen as ammonia. The amount of ammonia in the black peat is insignificant.

3. Practically all the nitrogen in the peats is of organic nature.

4. The bulk of the organic nitrogen, namely from two-thirds to three-quarters calculated upon the nitrogen in solution by boiling with acids is present in the form of monamino acids, about one-quarter in the form of amides and the rest of the nitrogen represents diamino acids.

5. Through weathering the organic nitrogenous bodies present in the brown peat change quite slowly.

6. The amount of water-soluble nitrogen in the brown peat increases somewhat through the natural process of weathering.

HOG CHOLERA SERUM.

Circular No 6.

Introduction.—The Bureau of Animal Industry has recommended for combating hog cholera a serum prepared from the blood of a hog so treated as to produce a great resistance to the disease. The Bacteriological Laboratory of the Michigan Agricultural College, East Lansing, is manufacturing this serum.

Preparation.—A pig which has passed through an attack or epidemic of hog cholera and is resistant to the disease or has been treated with serum and virus, or, in other words, has been artificially vaccinated against the disease, is treated with large quantities of blood (virus) from a pig very sick with hog cholera. After a short period, the blood from the pig so treated is drawn, the clot removed, and one-half per cent carbolic acid added. This constitutes the serum used for combating hog cholera.

Methods of Treatment.—There are two methods used in treating hogs for the prevention of hog cholera, viz: the "Serum-Simultaneous Method," and the "Serum-Alone Method."

"Serum-Simultaneous Method:" Each pig is injected with the proper doses of "Hog Cholera Serum" and "Hog Cholera Virus." The injections are made "simultaneously" or at the same time before the pig is released. This method is used in herds in which the disease does not exist or where the disease has just started. Pigs treated by this method are immune for six months to one year or perhaps for life. The method is not dangerous as a rule, but it is attended with greater danger than the "Serum-Alone Method." However, the resulting immunity is much longer than in the case of the "Serum-Alone Method" and the additional expense is not to be considered. Pigs that show an elevation of temperature or any other symptoms of hog cholera, or pigs that have been exposed to infection longer than one or two days are treated by this method at some risk. *We do not recommend this method at present.*

"Serum-Alone Method:" Each pig is treated with the proper dose of serum *only.* This method is to be used in herds where the disease already exists and is to be used on seemingly healthy pigs only. The earlier in the outbreak it is used, the greater the number of animals that may be treated with prospects for a successful outcome. Pigs already sick will probably not benefit by its use. Many pigs, apparently well, but already infected with the disease germs, can not be saved by the use of serum, although a number of them may be saved. Serum alone may also be used on pigs that it is desired to show at fairs or other public places for a short time where they may be exposed to infection.

Because of difficulties which we have experienced when using the "Serum-Simultaneous Method" in the field under different conditions

than those under which the serum has been tested, we do not recommend it or permit the virus to pass out of our hands for the present.

There is no danger in the use of the "Serum-Alone Method," and we heartily recommend it where hog cholera exists or in cases where immunity is desired for a short period.

FIGURE 2.

Separate the well from the sick or those to be treated from those not to be treated. If possible, mark in some way all those treated or all those not treated so that the results of the treatment may be accurately estimated. The pigs to be treated should be separated according to weight in pens or enclosures, all those requiring the same dose of serum being placed together.

The attendant holds the pig by the hind legs with the snout toward the ground and the inside of thighs or hams exposed to the operator. (See Fig. II).

Pigs weighing less than 100 lbs. can be easily held in this way. Larger hogs may be thrown on the back with the hind legs spread apart

and held securely. Hogs weighing over 200 or 300 lbs. can be treated while standing by inserting the hypodermic needle into the muscles on the inside and back portion of the ham, approaching the hog from the rear. An assistant holds the hog firmly by the tail. A "hogholder" or rope with slip-noose may be placed over the hog's upper jaw, the rope being then snubbed to a fence post. The treatment is not painful to the pigs which usually cease resistance while the injection is taking place.

TABLE OF DOSAGE.

Weight of Pig.	Dose of Serum. Minimum.	Maximum.
Sucking pig	10 cc.	15 cc.
30- 50 lbs	15 cc.	20 cc.
50 -75 lbs	20 cc.	25 cc.
75-125 lbs	25 cc.	30 cc.
125-175 lbs	30 cc.	35 cc.
175-225 lbs	35 cc.	40 cc.
225-275 lbs	40 cc.	45 cc.
275-325 lbs	45 cc.	50 cc.
325-375 lbs	50 cc.	55 cc.
375-425 lbs	55 cc.	60 cc.
425-475 lbs	60 cc.	65 cc.
475 lbs. and larger	65 cc.	70 cc.

Do not underestimate the weight of pigs for the sake of saving the price of a few cc. of serum.

Syringe.—A suitable syringe should be available for injecting the serum.

Responsibility of Bacteriological Laboratory.—The Bacteriological Laboratory does not recommend "Hog Cholera Serum" as a curative or remedial agent for hogs already suffering from hog cholera. The laboratory does recommend the use of "Hog Cholera Serum," prepared according to the method used by the Bureau of Animal Industry, as the only known preventive of hog cholera. Nothing is guaranteed. Michigan farmers must base their decision to use or omit the use of "Hog Cholera Serum" upon its merits as established by field tests. (See contract).

"Hog Cholera Serum" is a preventive of *hog cholera* only. It can not be expected to prevent hogs from dying or becoming sick from any other infection than that of *hog cholera* or from disorders caused by intestinal or other parasites. "Hog Cholera Serum" cannot replace proper care and feeding of swine or save hogs from dietary troubles other than those caused by the *virus of hog cholera.*

Contract.—A contract is required of all using the serum, releasing the laboratory from all responsibility in the matter.

Cost of Serum.—A charge of *two cents* per cubic centimeter is made for the serum. This is below the *actual cost* of production and testing.

Orders.—The amount of serum needed can be easily estimated in cubic centimeters from the table of dosage. Multiply the number of cubic centimeters by .02 and the product will be the cost in dollars and parts of a dollar. *Make orders clear and definite.*

Shipping.—The serum will be sent by express only. In order to reduce the labor and trouble for both parties concerned, it will be sent C. O. D.

More detailed directions and a blank contract will be sent with the serum.

Orders and Communications.—All requesting serum should address their communications to

THE BACTERIOLOGICAL LABORATORY,
Michigan Agricultural College,
East Lansing, Mich.

LACTIC CULTURES FOR DAIRY PURPOSES.

DIVISION OF BACTERIOLOGY AND HYGIENE.

Circular No. 7.

(For use of lactic cultures as starters*, see Bulletin 246).

The nature of a culture.—A "culture" consists of micro-organisms growing in some suitable food material as milk or beef-tea; or in another form the micro-organisms may be mixed with material such as starch, sugar or corn meal for ease of handling or shipping. When these micro organisms are planted in some fresh food, they begin to grow and multi ply very rapidly and produce changes in the food. A lactic culture con sists of lactic organisms in a suitable food.

Changes produced by cultures.—Bread is made light by the addition of a yeast cake (yeast mixed with starch or corn meal). The yeast cells grow, multiply, and, in so doing, produce gas which makes the bread light. Milk sours because certain micro-organisms or germs get into it, grow and multiply. These micro-organisms produce an acid from the sugar in the milk. This acid acts upon the milk in such a manner as to curd it. Sometimes, in spite of care, other germs or micro-organisms get into the milk and make it ropy or stringy; sometimes the milk tastes and smells like rancid butter; sometimes, or perhaps often, its flavor and aroma are not what they should be. At such times, good butter or cheese cannot be made. Accordingly, a culture is employed in cream or milk, as a yeast cake for making bread, to induce the right kind of change or fermentation.

Kinds of cultures.—Bread can be made without yeast or a culture, so can butter be made without a "culture." Nature will furnish the organisms many times for the occasion and they will be just as good as any that can be furnished; but many times nature will furnish organisms or a culture that will not be desirable, in other words, the bread will "go off," or the milk or cream will not ripen properly. This leads to complete loss or partial loss by deterioration in the value of the products. For this reason, the leading creameries and cheese factories aim at avoiding these losses or deterioration in products by supplying what nature sometimes or frequently fails to supply—a good culture of lactic micro-organisms.

*The term "starter" has come into common use and is used so indiscriminately that we have thought it better to employ a more specific term as well as the true term, *"lactic culture."*

What a lactic culture does.—If a culture is developed satisfactorily, and the milk or cream properly managed before and after the addition of a culture,

(a) *the correct ripening of milk or cream will follow,*
(b) *the product will be more uniform,*
(c) *the flavor and aroma of the product will be improved,*
(d) *the product will keep better.*

What a culture needs.—In order to have a culture produce its best results, it needs

(a) *to be properly and carefully selected,*
(b) *to be transferred often or, in other words, given new food frequently,*
(c) *to be cultivated away from other micro-organisms as corn away from weeds,*
(d) *to be maintained at a temperature which will keep it vigorous,*
(e) *clean milk or cream to develop in, or milk that does not contain too many germs of other kinds,*
(f) *pasteurized milk or cream, in which most of the weed germs have been killed, if clean milk or cream cannot be obtained.*

What will destroy the value of a culture.—There are certain things which work injury to a lactic culture or completely destroy it or its effect.

(a) *If many other kinds of germs become mixed with it some of the kinds will in time certainly injure or destroy its value. It must be kept pure.*
(b) *If the temperature is too cold or too warm, it will gradually cease to grow or its vigor will be greatly reduced.*
(c) *If the micro-organisms are kept too long in their own soured milk, or in their own food material in which they have been growing, they will stop growing and gradually die out. Their own products, if allowed to accumulate in too large quantities, will kill them off.*
(d) *If milk has been allowed to change in one way or another, there is little opportunity of rendering it good by the addition of a starter. It would be like diluting a big lot of sin with a bit of good.*
(e) *Even pasteurizing such milk means only the active agents of evil are checked, but the products of evil still remain behind. While a starter will do more good in this case, it must not be expected to correct all the mischief done.*
(f) *Many times a large amount of starter (30%-50%) is added to poor milk or cream. This does good by substituting 50% of good starter for 50% of evil starter. It works commercially very well when butter is very scarce, but it means no more than adding 10% of alcohol to grape juice to make wine.*

The care of a culture.—No matter how good the yeast culture may be, if a housekeeper does not know how to make bread, the yeast culture cannot give good results. Again, if the housekeeper knows how to make good bread, and the yeast culture is bad, failure follows. It is necessary, in order to have a good bread, to have a good bread-maker and a good yeast culture. This is likewise true of the lactic culture and the dairy product. The lactic culture is maintained satisfactorily only through

watchful and painstaking care. It must be nursed with skill. A careless or indifferent individual had better not undertake the management of a lactic culture unless he desires a course of training. A man who cannot keep the weeds out of his corn, or the woman who hasn't the gumption to keep flies out of butter, cannot make a success of the lactic culture, and we do not encourage them in undertaking its management. Skill is needed for good butter-making and good cheese-making, likewise it is needed for manipulation of a culture. It will be useless for those, who do not mean to make the best dairy products, to try handling the culture.

The purpose of this laboratory.—We assume that the value of the lactic culture is well established, but we feel that its use is not sufficiently extensive. The reason for this doubtless is found in the fact that it is something quite new. There are difficulties to surmount before the management of the culture is understood and within the grasp. This laboratory desires to help those who wish to employ it and will send directions for using and maintaining it.

Directions for using and maintaining.—Detailed directions will be sent with each culture. These will state how the culture is to be handled, how it is to be maintained and how it is to be built up for adding to milk or cream.

Likelihood of injury from the use of a lactic culture.—There is no possibility of doing injury with this starter. It may be added to the milk you drink and you will be none the worse for it.

Conditions under which cultures are sent out.—Upon receipt of cost and upon condition that the report blank, enclosed with the culture, will be very carefully filled out and returned to this laboratory, cultures will be forwarded with full directions for use. The laboratory will be able to discover from this report any difficulties that are plainly evident, and thus to determine whether or not it will be wise to continue furnishing cultures to parties who may not follow directions or are careless in their use.

Prepared by

The Bacteriological Laboratory.

East Lansing, Michigan.

TUBERCULOSIS.

DIVISION OF BACTERIOLOGY AND HYGIENE.

Circular No. 8.

THE EXTENT OF THE DISEASE.

It is exceedingly difficult to make a fair statement of the prevalence of tuberculosis as it exists in humans and cattle. Objections of diverse natures may be offered for nearly every form of statistics presented. Under the stress of the moment, urged on by the agitation in newspapers and magazines as well as field orators, it would not be strange to overestimate the prevalence of the disease and to minimize the ease of eradication.

To furnish the reader with an intelligent idea of the prevalence of the white plague, we are offering quotations from different sources, believing that from them some adequate conception can be formed. Moreover, it is fair to assume, in the light of past and present experiences, that this disease will not be eliminated from our midst in ten years, or even twenty years although its progress may be checked. We should not enter upon its eradication spasmodically, but with a persistent determination to stay with it as long as necessary to subjugate it.

2,412 people died from this disease in Michigan in the year 1908.

Regarding the loss from wage earnings, the cost of the patient in suffering, medical treatment, medicines, nursing, board and care; regarding the suffering undergone by those who are more or less dependent upon the patient and the sacrifice entailed by near relatives and friends; regarding the loss sustained by the community through the destruction of one of its members,—regarding all of these possible sources of loss and sacrifice, then it is easily understood what this disease really means.

"A chart showing before and after conditions of twelve families where the father had tuberculosis shows a decrease of an average from $12.66 per week before the disease to $4.16 per week after the man had been forced to give up work. This was earned by the woman. In fifty consecutive families receiving help from the same Society (Chicago Relief and Aid Society) in some instances the disease on the part of the woman or a child, the average income was $4.50 per week.

"In a recent examination of 150 families by Doctor Theodore B. Sachs, 25 to 30 per cent of all the children in these families showed signs of infection. This disease forces children out of school at the earliest possible age, exhausts family resources and vitality and fastens itself on the weakened members." (Kingsley).

"The death rate from tuberculosis in all its forms in the United States is estimated at 164 per annum per 100,000 of population, and the number of deaths in 1906 at 138,000. At this rate, of those now living in the United States, 5,000,000 people will die of tuberculosis.

The "expectation of life" lost (though estimated on a specially high mortality rate) is at least 24 years, of which at least 17 fall in the working period. The average period of disability preceding death from tuberculosis exceeds *three years*, of which the latter half is a period of total disability.

"The money cost of tuberculosis, including capitalized earning power lost by death, exceeds $8,000 per death. The total cost in the United States exceeds $1,100,000,000 per annum. Of this cost, about two-fifths, or over $440,000,000 per annum, falls on others than the consumptive." (Fisher).

"The economic loss to a community from tuberculosis is made up of several elements, three of which may be roughly estimated with the aid of existing information. These are, first,—the loss resulting from the diminished earnings and increased expense during the period between the onset of the disease and the death of the patient; secondly,—the loss of net earnings between the actual date of death and the time when death would probably have occurred had the person not been attacked by tuberculosis; and thirdly,—the momentary loss to farmers and dairymen each year resulting from bovine tuberculosis. The first element has been roughly estimated as $11,184,750 in New York State. The second is much greater. It seems probable that the prospective earnings of the 16,570 persons who died of tuberculosis in New York State in 1907 was $52,251,757.

"The annual loss to owners of cattle must be at least $1,500,000 and the total loss from all sources in money cannot well be less than $65,000,000 a year. The loss in expectation of life is equally striking. An infant would have its expectation of life at birth increased by about two and a half years if tuberculosis were to disappear while other conditions remained unchanged." (Wilcox).

TESTS SUPERVISED BY THE EXPERIMENT STATION AND THE STATE VETERINARIAN OF WISCONSIN. (RUSSELL AND HOFFMAN).

	Experiment station tests.		State veterinarian tests.		Totals.	
	Animals tested.	Animals affected.	Animals tested.	Animals affected.	Animals tested.	Animals affected.
1901	425	84	.....	.....	425	84
1902	306	42	807	242	1,113	284
1903	182	5	735	166	914	171
1904	688	44	1,316	331	2,004	375
1905	726	44	929	209	1,655	253
1906	5,842	726	3,876	1,000	9,718	1,726
1907	10,750	470	5,066	821	15,816	1,291
1908	27,202	1,041	13,791	1,293	40,993	2,334
Total	46,121	2,456	26,517	4,062	72,638	6,518

"Statistics of the United States Federal meat inspection for the fiscal year ending June 30, 1908, covering 53,973,337 animals, or more than one-half of all those slaughtered for food in the country, show the following percentages of tuberculosis: Adult cattle, 0.961; calves, 0.026; hogs, 2.049; sheep and goats, 0. The proportion of tuberculosis is probably higher in animals slaughtered without inspection.

"Reports of tuberculin tests made in the 15 years from 1893 to 1908 by Federal, State, and other officers with tuberculin prepared by the Bureau of Animal

Industry have been carefully analyzed and tabulated. Out of 400,000 cattle tested (mostly dairy cattle) there were 37,000 reactions or 9.25 per cent.

"From these two classes of statistics it is concluded that on an average about 10 per cent of the milch cows, 1 per cent of other cattle, and 2 per cent of the hogs in the United States are affected with tuberculosis, the average percentage for all cattle being estimated at 3.5.

SOME RESULTS OF TUBERCULIN TESTS OF CATTLE BY STATE AND FEDERAL OFFICERS WITH TUBERCULIN PREPARED BY THE BUREAU OF ANIMAL INDUSTRY, 1893, TO JULY 31, 1908, INCLUSIVE.

States.	Number of cattle tested.	Number reacting.	Percentage reacting.
California	9,618	1,112	11.56
Connecticut	6,080	852	14.01
Illinois	7,120	790	11.09
Indiana	2,935	246	8.38
Iowa	4,020	778	19.35
Maine	3,264	149	4.56
Massachusetts	86,223	11.853	13.75
Michigan	2,155	351	16.29
Minnesota	60,733	3,031	4.99
Missouri	1,680	133	7.92
New Jersey	3,293	828	25.14
New York	4,034	565	14.00
North Carolina	1,207	208	17.23
Ohio	2,933	425	14.49
Oregon	1,466	351	23.94
Vermont	162,570	10,628	6.54
Washington	2,779	455	16.37
Wisconsin	32,297	3,477	10.77

"The economic loss on account of tuberculosis in food-producing animals is heavy. The loss on animals in which tuberculosis is found in the Federal meat inspection is estimated at $2,382,433 annually, and if the same conditions were applied to animals slaughtered without Federal inspection the annual loss on all animals slaughtered for food in the United States would be increased to $4,354,855. The stock of animals on hand is also depreciated in value because of tuberculosis. Assuming that living tuberculous milch cows are annually depreciated to the extent of one-tenth of what the loss would be if they were slaughtered, other cattle one-third, and hogs one-half, the total annual depreciation amounts to $8,046,219. The annual loss from decreases in milk production is estimated at $1,150,000, and there is also some loss from impairment of breeding qualities, etc. Taking all these items into account, the aggregate annual loss because of tuberculosis among farm animals in the United States is estimated at not less than $14,000,000." (Melvin).

"We have tested 22 herds, containing 1,022 cows in all, of which 326 or 31.9% reacted. Eighty-two per cent of the herds were infected. These figures include only whole herds of five cows or over, which had never been tested." (Ward, California).

"During the two years, 1903-4, that Montana's Meat and Milk Inspection Law was enforced, the dairy cattle of each county were tuberculin tested. Four of these have, during years past, drawn heavily on Eastern States for dairy cattle, all the others obtaining their dairy herds from range cattle. Not a single cow reacted in these counties, while those with eastern dairy cattle constituting the majority of the herds, or having been the foundation of them, gave from eighteen to thirty per cent of reactions." (Knowles, Montana).

"My attention was first directed to this in 1900 (Tuberculosis in Range Cattle in California), when in conducting post mortem examinations of a bunch of

steers, I found 0.9 of 1 per cent showing tubercular lesions. Careful records were kept of this range—hereafter known as Range I—till April 18, 1906, when unfortunately they were destroyed by fire, but these records showed a constant increase in tuberculosis, until at the end of 1905 we were getting over 9 per cent tubercular.

"From April 18th to the end of 1906 there were killed, from Range I, 1,844 cattle (bulls, steers, and cows), with 203 tubercular.

"In 1907—from Range I—1,288 steers, 62 showing lesions of tuberculosis. From other ranges in the State, 5,382 cattle of all kinds, with 181 tubercular. From Nevada ranges, 433 cattle, 13 tubercular.

In 1908, January 1st, to June 30th—from Range I—1,153 cattle, 60 showing tuberculosis. From other ranges in the state, 26,330 cattle, 1,121 tubercular. From ranges of other states, 10,159 cattle, 33 tubercular." (Baker).

"Tuberculin work for the year ending August 1st, 1908.—Registered cattle tested, 1,329; number of reactions, 490, or 36.8 per cent. Grade cattle tested, 25,887; number reacted, 2,000, or 7.7 per cent." (Reynolds, Minnesota).

TRANSMISSION OF THIS DISEASE.

Tuberculosis is due to the growth of a specific micro-organism which may be transmitted from man to man. It is possible to control it the same as any other contagious or infectious disease. Interest centers in its possible transmission from cattle and swine to man because Koch has said that bovine tuberculosis and human tuberculosis are distinct. Since Koch's utterance, much work has been done, and nearly all investigators are in accord in saying that bovine tuberculosis may be transmitted especially to infants whose only diet is milk, and whose organs are so sensitive. Tuberculosis does not break out like measles, but may lie dormant in the body awaiting a time when the vitality is lowered before it sets forth to slay. Doubtless, most human tuberculosis is contracted from human sources, but by no means is the bovine source negligible. Koch admits this possibility, even to a certain percentage of cases.

HOW TRANSMITTED FROM CATTLE.

It is generally conceded that the most common avenue is through the milk; rarely through the meat, because of the heating.

Schroeder says that 40% of tuberculous cattle give off the germs of the disease in their feces.

Most milk contains some feces, because of the dirt, hairs, etc., which find their way into it.

Hess found 16% of milk samples, picked up indiscriminately in New York City, were able to produce tuberculosis in guinea pigs.

WHAT IT MAY MEAN TO THE CATTLE OWNER.

This disease is readily transmissible from one animal to another,—by water, by food, by licking, by coughing, by close stabling and by other means. It may be transmitted from one herd to another by means of sales, by careless use of sires, by the indiscriminate distribution through the community of skimmed milk, and whey from the common vats of creameries and cheese factories. It spreads slowly but as surely as any other infectious disease.

To economize, act at once to ascertain its presence in the herd and to check its spread.

HOW DETERMINED.

The use of tuberculin on the 400,000 animals by the Bureau of Animal Industry shows that the test is reliable in 98.81% of cases. Can you find any other diagnostic that will do as well? *It is perfectly safe to use.*

The test may be mastered by any bright young man who may wish to study into its details.

STATE WORK.

Reynolds gives the following results of the state of Minnesota for the year ending August 1, 1908:

Registered cattle tested..	1,329—tuberculous	490 or	36.8%
Grade cattle tested.....	25,887—tuberculous	2,000 or	7.7%
Total cattle tested...	27,216—tuberculous	2,490 or	9.3%

Cost to State,—

Grade cattle (reimbursement, freight and yardage) .	$27,605 00
Registered cattle (reimbursement, freight and yardage) .	17,460 00
Cost of office work, $70.20 per 1,000 tested.....	1,809 44
Cost of disinfection, $1.00 per head.....	27,216 00
Testing at 50 cents per head.....	13,608 00
Total	$87,698 44

This represents less than one per cent of the 3,000,000 cattle of the state and a single test. It does not consider the possible increase which may be greater, nor testing those herds having the disease more than once.

It may be desirable to test herds which do not have the disease every few years and it is established that the herds which have the disease will have to be tested twice each year for the first two or three years, then once each year over a period of perhaps ten years or more.

What does it mean, therefore, to test all of the cattle of Minnesota, and then follow up all the herds which may have tuberculosis present over a period of years?

Michigan probably has 2,500,000 cattle.

OUTLOOK.

Unless a specific remedy is found for this disease, there is but one way of checking its ravages; this is by extermination before this disease has gone too far.

The sooner it is fully realized that the struggle against this disease is largely individual, and the sooner the matter is taken up by stock owners, the less will be the loss and the greater the efficiency of the work.

Prepared by

The Bacteriological Laboratory.

East Lansing, Michigan.

VINEGAR AND ITS MAKING.

DIVISION OF BACTERIOLOGY AND HYGIENE.

Circular No. 9.

What is vinegar.—Vinegar is a product resulting from a specific fermentation instituted by micro-organisms.

Source.—Vinegar may be produced from apple juice, grape juice, or, in general, fruit juices or vegetable juices containing sugar, or grain in the form of solution, or simply suitable sugar solutions. It is commonly made from apple juice, grape juice, malt solutions, suitable sugar solutions, or, if we confine our minds to the immediate acid production, it would result from the acid fermentation of "hard cider," wine, beer, or alcoholic solutions coming from the change of sugar to alcohol.

Fermentation.—The sugar present in the fruit or vegetables is changed by yeasts (micro-organisms) into alcohol, and then this alcohol is changed by bacteria (micro-organisms) into acetic acid (the acid of vinegar). These steps represent the simple changes. There are secondary products, other than alcohol and acetic acid, formed in addition to the above, which we need not consider in this connection.

Laws requirements.—Act No. 71, Sec. 2, Public Acts, 1897, Michigan)—"All fermented vinegar not distilled shall contain not less than one and three-fourths per cent, by weight, upon full evaporation (at the temperature of boiling water) of solids, contained in the fruit or grain from which said vinegar is fermented, and said vinegar shall contain not less than two and a half tenths of one per cent ash or mineral matter, the same being the product of the material from which said vinegar is manufactured. And all vinegar shall be made wholly from the fruit or grain from which it purports to be or is represented to be made, and shall contain no foreign substance, and shall contain not less than four per cent, by weight, of absolute acetic acid."

Conditions of fermentation.—In order to establish the *proper fermentation* leading to *a good* vinegar the following conditions must be observed:

a. The juice, whether fruit, vegetables, or grain in the form of solution must contain sugar in sufficient quantities to produce alcohol. In case of starch as in grain, it is necessary to convert the starch into a sugar. It follows that, unless the ripening of fruits proceeds to the point of sugar formation, or there is sugar in the vegetables, or the starch in the grain is converted into sugar, the production of vinegar is inter-

cepted. 100 parts by weight of sugar should yield about 50 parts by weight of acetic acid.

b. Yeast-cells (organisms) should be present in sufficient numbers to control the first stage of the fermentation and give rise to alcohol by a change of the sugar. There are good yeasts and bad yeasts just the same as good plants and bad plants. To make good vinegar, a good and suitable yeast is required. Nature furnishes this yeast many times, but frequently only an unsuitable yeast, giving rise to an undesirable vinegar, is provided by natural processes.

c. Specific bacteria (organisms) are needed to change the alcohol into acid,—the second and last stage in vinegar fermentation. Sometimes these bacteria are very satisfactory and active, as they are found in the "mother-of-vinegar," but again they are not. They must be present and they must be active to produce vinegar, and they must be in sufficient numbers to control the second stage of the fermentation.

d. The changes taking place in the production of vinegar require oxygen of air (about 20% of the air is oxygen), accordingly, it is not desirable to fill a barrel so full that there is not an extensive surface over the liquid, the juice. The free access of air is absolutely essential to the production of vinegar. Note methods of manufacture in vinegar factories. The micro-organisms require an abundance of air for carrying on their work.

e. In order that the micro-organisms, both yeasts and bacteria, may flourish, a *suitable temperature* must be maintained. Like other plants, micro-organisms require a suitable temperature. 65° F. to 75° F. may be regarded as the best range. After the fermentation is complete it is desirable to store the barrel tightly bunged in a cool cellar.

Off-fermentations.—Fermentations other than those leading to the production of vinegar not infrequently occur, due to other micro-organisms than those producing vinegar, or to a lack of air, or to an improper temperature or to the character of the fruit or vegetable juices or grain extracts. Realizing that these off-fermentations happen often, the *Bacteriological Laboratory* is aiming to assist farmers as much as possible by furnishing cultures to initiate the best possible vinegar fermentation.

Container.—If natural fermentation is depended upon, old vinegar barrels in which good vinegar has been produced are the best. New barrels of any kind should be washed and scalded. After the barrels have been cooled, the barrels should be rinsed with a little good vinegar or mother-of-vinegar before the addition of the juice. *If a proper fermentation is sought and assurance wanted, then a culture should be secured.*

Alcohol-acetic culture.—This consists of a tested yeast mixed with tested acetic bacteria; both classes of micro-organisms are essential to the production of vinegar.

Responsibility of the laboratory.—While these cultures give excellent results, not being in position to control their use completely, it is understood that this laboratory can assume no responsibility in the matter. No injury can come from the use of cultures, however used.

Prepared by

The Bacteriological Laboratory.

East Lansing, Michigan.

EXPERIMENT STATION.

REPORT OF SECRETARY AND TREASURER.

The following shows the receipts and disbursements of the Experiment Station for the year ending June 30, 1910:

		Dr.	Cr.
July 1, 1909	To balance	$1,634 32	
July 19, 1909	received from U. S. Treasury	7,000 00	
Oct. 11, 1909	received from U. S. Treasury	7,000 00	
Jan. 12, 1010	received from U. S. Treasury	7,000 00	
Apr. 12, 1910	received from U. S. Treasury	7,000 00	
June 30, 1910	license fees, 204 brands com'l fertilizers	4,080 00	
	farm receipts, etc	345 22	
	from State appropriation, South Haven	2,100 00	
	from State appropriation, U. P. Experiment Station	3,000 00	
	South Haven Experiment Station, receipts	440 67	
	U. P. Experiment Station receipts	581 40	
	by disbursements as per vouchers filed in office of the State Auditor General		$37,857 09
	Balance on hand		2,324 52
		$40,181 61	$40,181 61

Three hundred fifty thousand regular bulletins, twenty eight thousand five hundred special bulletins, fifteen thousand technical bulletins and one hundred fifty thousand circulars have been issued by the Experiment Station during the fiscal year.

DISBURSEMENTS ON ACCOUNT OF U. S. APPROPRIATION.

	Hatch Fund.	Adams Fund.	Total.
Salaries:			
Director and other administrative officers; clerks, No. 4..	$1,870 00	$250 00	$2,120 00
Scientific staff, No. 5	1,068 15	1,433 15	2,501 30
Assistants to scientific staff, No. 19	4,535 02	4,825 10	9,360 12
Labor:			
Monthly employees	1,133 26	524 50	1,657 76
Weekly, daily and hourly as needed	1,774 36	566 50	2,340 86
Publications:			
Halftones, mailing lists, etc	213 31	.....	213 31
Postage and stationery:			
Postage	145 73	15 22	160 95
Stationery	106 67	3 20	109 87
Telegraph	4 37	3 22	7 59
Freight and express	214 22	184 55	398 77
Heat, light, water and power	62 43	.....	62 43
Chemical supplies:			
Chemicals	248 08	548 28	796 36
Other supplies	362 70	1,540 62	1,903 32
Seeds, plants and sundry supplies:			
Agricultural	265 65	.....	265 65
Horticultural	353 50	.....	353 50
Botanical	4 05	48 20	52 25
Entomological	52 16	7 85	60 01
Bacteriology	45 70	1,442 52	1,488 22
Chemistry	145 03	5 36	150 39
Director's office	4 75	.....	4 75
Soil Physicist	.....	3 16	3 16
Fertilizers	433 84	3 93	437 77
Feeding stuffs	.....	276 60	276 60
Library:			
One arch. fuer Hygiene	15 00	.....	15 00
One Biochemische Zeitschr'ft	21 00	.....	21 00
One Biochemische Central blatt Vol. X	10 00	.....	10 00
One Central blatt F. Bakter Vol. 52-55	14 40	.....	14 40
One Central blatt F. Bakter Vol. 45-47	10 08	.....	10 08
One Central blatt F. Bakter Vol. 25-27	10 08	.....	10 08
One Chemisches Central blatt 1910	20 00	.....	20 00
One Zeitschr'ft fuer Hygiene Vol. 64-66	16 50	.....	16 50
118 Volumes bound one-half morocco	112 10	.....	112 10
One Brochemisches Central blatt	10 00	.....	10 00
One Brochemisches Zeitschr'ft Vol. 19-21	9 00	.....	9 00
Other purchases	322 78	16 09	338 87
Tools, implements and machinery:			
New purchases	388 26	86 12	474 38
Repairs	8 95	.....	8 95
Furniture and fixtures:			
One No. 1235 cabinet	26 00	.....	26 00
One desk	19 80	.....	19 80
Two sections book case	16 00	.....	16 00
One electrotype sec	8 00	.....	8 00
One refrigerator	55 00	.....	55 00
Other purchases	54 30	.....	54 30
One 12-drawer Macey cabinet	.....	12 00	12 00
Other purchases	.....	6 88	6 88
Scientific apparatus:			
One set weights	13 50	.....	13 50
One anal balance	78 00	.....	78 00
Six seed samplers	18 00	.....	18 00
Two Hastings triplets	13 50	.....	13 50
One camera korone with case	30 00	.....	30 00
One camera F 6 Voighlender	36 00	.....	36 00
Other purchases	11 77	.....	11 77

U. S. APPROPRIATION.—*Concluded.*

	Hatch Fund.	Adams Fund.	Total.
Scientific apparatus—Con.			
One abbes spectroscopic ocular		$50 00	$50 00
One centrifuge		10 00	10 00
One boiler plate dome protector		70 00	70 00
One arm to carry four vessels		40 00	40 00
One 2 H. P. Crocker wheeler motor complete		90 20	90 20
One projection table		20 00	20 00
One large photo micrographic camera		72 50	72 50
Other purchases		371 58	371 58
Live stock:			
Swine		349 99	349 99
Traveling expenses:			
In supervision of station work	$101 47		101 47
In connection with investigations under the Adams act		122 68	122 68
For other purposes connected with station work	492 53		492 53
Contingent expenses	15 00		15 00
Total			$28,000 00

DISBURSEMENTS OF EXPERIMENT STATION MONEYS—OTHER THAN RECEIVED FROM UNITED STATES TREASURER.

Salaries	$2,607 95	
Labor	4,652 50	
Publications	305 35	
Postage and stationery	409 52	
Freight and express	273 36	
Chemical supplies	282 86	
Seeds, plants and sundry supplies	893 15	
Fertilizers	25 35	
Library	6 65	
Tools, implements and machinery	27 54	
Live stock	7 00	
Traveling expenses	308 86	
Furniture and fixtures	57 00	
		$9,857 09
Balance		2,324 52
Total		$12,181 61

MICHIGAN
STATE AGRICULTURAL SOCIETY.

MICHIGAN STATE AGRICULTURAL SOCIETY.

REPORT OF THE TRANSACTIONS OF THE SOCIETY FOR THE YEAR ENDING JUNE 30TH, 1909.

OFFICERS FOR 1909-10.

President—Fred Postal, Detroit.

Vice-President—L. W. Watkins, Manchester.

Secretary—I. H. Butterfield, Detroit.

Treasurer—John McKay, Romeo.

EXECUTIVE COMMITTEE.

(Terms Expire January, 1910.)

A. J. Doherty ..... Clare
W. J. Galbraith ..... Calumet
Wm. J. Terney ..... Roscommon
L. C. Holden ..... Sault Ste. Marie
F. B. Ransford ..... Caro
W. W. Collier ..... Pontiac
L. R. Taft ..... East Lansing
Geo. B. Horton ..... Fruit Ridge
D. D. Aitken ..... Flint
Chas. L. Edwards ..... Carleton

(Terms Expire January, 1911.)

T. F. Marston ..... Bay City
Archibald J. Peek ..... Jackson
A. E. Stevenson ..... Port Huron
C. A. Tyler ..... Coldwater
Nicholas J. Whelan ..... Holland
Wm. Dawson ..... Sandusky
Vincent V. Green ..... Detroit
Lawrence W. Snell ..... Highland Park
Geo. Kelly ..... North Branch
*F. J. Lessiter ..... Clarkston

EX-PRESIDENTS.

(Members Ex-Officio.)

T. W. Palmer ..... Detroit
John T. Rich ..... P. O. Port Huron
I. H. Butterfield ..... Detroit
E. Howland ..... Pontiac
Eugene Fifield ..... Bay City

*To fill vacancy. Daniel Thomas declined re-election.

STANDING COMMITTEES AND EXECUTIVE SUPERINTENDENTS.

Business—A. J. Doherty, Lawrence W. Snell, I. H. Butterfield.
Finance—D. D. Aitken, Eugene Fifield, T. F. Marston.
By-Laws and General Rules—W. J. Galbraith, N. J. Whelan, V. V. Green.
Premium List—Eugene Fifield, I. H. Butterfield, C. A. Tyler, A. E. Stevenson, D. D. Aitken, L. R. Taft, W. J. Terney.
Reception—John T. Rich, L. C. Holden, Geo. B. Horton.
Program—The President, Chief Marshall and Business Committee.

SUPERINTENDENTS.

Cattle—C. A. Tyler.
Assistant Superintendent, F. J. Lessiter.
Horses (except for Speed)—L. W. Watkins.
Horses (Speed)—Eugene Fifield.
Sheep—W. E. Boyden.
Swine—George Kelly.
Poultry—L. C. Holden.
Farm and Garden Products—W. J. Terney.
Dairy—Lawrence W. Snell.
Apiary—F. B. Ransford.
Farm Implements and Machinery—Vincent V. Green.
Vehicles—Chas. L. Edwards.
Main Building—Wm. Dawson.
Art—A. H. Griffith.
Needlework—Mrs. Belle F. Clark.
Horticulture—Prof. L. R. Taft.
Educational—Thos. M. Sattler.
Gates—General Superintendent.
Marshal and Superintendent of Police—A. J. Peek.
Concessions—The Business Committee.
Transportation—A. E. Stevenson.

THE FAIR OF 1909.

Was held September 2nd to 10th inclusive. The weather was good throughout. The attendance was somewhat less than at three previous fairs. The entries and exhibits kept to the usual standard. Some farther improvements were made on the grounds; notably in over 25,000 square feet of concrete walk, and in the erection of a speed barn 24x248 feet with 48 box stalls. Continued repairs on buildings and improvement of roads were made.

PROCEEDINGS OF THE BUSINESS AND EXECUTIVE COMMITTEES.

Few meetings of the business committee were held. The duties of that committee being largely assumed by the General Superintendent.

The business committee and the finance committee held a joint meeting on June 21st, 1909.

On motion it was resolved, "That the treasurer be authorized to sell admission tickets to the next fair to be held Sept. 2-10 at advance sale at the following rates. Twenty-five thousand (25,000) at thirty cents each. The next fifteen thousand, at thirty-one cents each. Ten thousand more at thirty-one cents each, if sold by August 1st. And ten thousand more at thirty-one cents each, if sold by August 15th. Also forty thousand tickets to be sold in country places at thirty cents each."

On motion of Mr. Doherty, Mr. Fifield was authorized to contract for the pool privilege at the fair for $151.00 per race, one-half to be paid in advance.

The matter of erecting an administration building being under consideration. It was moved that it be indefinitely postponed. Motion carried. On motion adjourned.

EXECUTIVE COMMITTEE.

The executive committee met at the office of the president on the fair grounds, Monday, September 6th, at nine o'clock, a. m. Called to order by the president.

Present, McKay, Snell, Tyler, Aitken, Green, Dawson, Marston, Kelly, Stevenson, Doherty, Lessiter, Edwards, Butterfield, Fifield, Peek, Terney, Taft and the president.

On motion of Mr. Stevenson the caucus and meeting of the society was ordered to be held on the west porch of the Michigan building at 12 m. on Wednesday, Sept. 8th.

On motion of Mr. Doherty, Mr. F. J. Lessiter, W. H. Dawson and T. F. Marston were appointed judges of election.

The Press Booth was named as the place of holding the election.

A parade of live stock was ordered for Thursday, Sept. 9th, at 11 o'clock, a. m.

On motion of Mr. Stevenson it was ordered that live stock not on the grounds by Monday morning, Sept. 6th, at 9 o'clock a. m., be not permitted to show for premiums.

Adjourned to meet Tuesday, Sept. 7th, at 9 o'clock a. m.

MEETING OF THE SOCIETY.

Held pursuant to call of the executive committee at the Michigan building on the grounds on Wednesday, Sept. 8th, at 12 m.

Called to order by the president.

On motion of Mr. Stevenson, the president was requested to appoint a committee of three to present names for nomination of officers to be voted for at the annual election to be held Sept. 9th. Carried.

The president appointed Mr. Fifield, W. F. Johnston, A. W. Freer.

The committee appointed by the executive committee at its annual meeting in January to prepare some revision of the Constitution to be submitted to the society reported as follows: Your committee on revision of the Constitution appointed by the executive committee at its annual winter meeting make the following report:

We recommend that Article 5 of the Constitution be amended to read as follows:

Article 5. The executive committee shall determine the time for holding each annual fair of the society and it shall call that meeting and fair at such times as it shall judge best, between the fifteenth day of August and the fifteenth day of October giving at least sixty days notice thereof.

Also, that Article eleven, be made to read as follows: Article eleven. Any male citizen of Michigan over twenty-one years of age may become a member of this society for one year, on payment of two dollars ($2.00) to the secretary, who shall issue a certificate therefor.

D. D. AITKEN,
EUGENE FIFIELD,
Committee.

Mr. Aitken moved that the report be accepted and adopted, and that the amendments proposed be placed on a ballot to be voted on at the annual election to be held Sept. 9th. Motion carried unanimously.

The committee on nomination of officers to be voted for at the annual election, reported as follows. Your committee on nominations present the following report:

For President—Fred Postal.

For Vice-President—Thos. E. Newton.

For Secretary—I. H. Butterfield.

For Treasurer—John McKay.

For members of the executive committee for two years: A. J. Doherty, Clare county; D. D. Aitken, Genesee county; L. R. Taft, Ingham county; W. W. Collier, Oakland county; W. J. Terney, Roscommon county; F. B. Ransford, Tuscola county; Henry Bowen, Lenawee county; John F. O'Keefe, Saginaw county; Sherman L. Handy, Chippewa county; Geo. W. Dickinson, Oakland county. To fill vacancy for one year, F. Jay Lessiter, Oakland county.

On motion of Chas. L. Edwards, the report was accepted and adopted, and the names ordered placed on a ballot. On motion adjourned.

ELECTION.

The annual election of officers of the society was held at the Press Booth in the administration building on Thursday, September 9th, in charge of the judges of election appointed by the executive committee. The polls were open from nine o'clock a. m. to five o'clock p. m.

At the closing of the polls, the votes were counted with the following results, as reported by the judges:

Whole number of ballots cast	59
For President, Fred Postal had	49
For Vice-President, Thos. E. Newton had	56
For Secretary, I. H. Butterfield had	59
For Treasurer, John McKay had	58

For members of Executive Committee for two years:

A. J. Doherty	45 votes.
D. D. Aitken	59 votes.
L. R. Taft	59 votes.
W. W. Collier	59 votes.
W. J. Terney	59 votes.
F. B. Ransford	59 votes.
Henry Bowen	59 votes.
John F. O'Keefe	59 votes.
Sherman L. Handy	59 votes.
Geo. W. Dickinson	59 votes.

To fill vacancy for one year:

F. Jay Lessiter	59 votes.

Each of these persons having received a majority of all the votes cast, was declared duly elected to the respective offices named.

The vote on Amendments to the constitution were as follows: To amend Article five, Yes, 55. No, none. To amend Section eleven, Yes, 53. No, one.

The Amendments were declared carried.

Signed WM. DAWSON,
GEO. KELLY,
F. JAY LESSITER,
Judges of Election.
I. H. BUTTERFIELD,
Secretary.

COMMITTEE MEETINGS.

The business and finance committees met at the office Sept. 23, 1909. Routine business connected with the settlement of accounts was transacted and the committee adjourned.

ANNUAL WINTER MEETING OF THE EXECUTIVE COMMITTEE.

The annual winter meeting of the executive committee was called by the President to meet at Detroit on Monday, January 10th, 1910, at eight o'clock, p. m.

The meeting was called to order by the president. Roll called. There were present, Messrs. Postal, McKay, Butterfield, Doherty, Aitken, Terney, Ransford, Taft, Holden, Marston, Peek, Tyler, Stevenson, Dawson, Green, Kelly, Lessiter, Fifield.

Minutes of last meeting read and approved.

The president delivered his address, an abstract of which is as follows:

Gentlemen of the executive committee of the Michigan State Agricultural Society.

The fair of 1909, shows somewhat reduced receipts, I enumerate some of the causes, which to my mind contributed to this end. First: We arranged for Auto races for Friday and Saturday of the first week, and as you are aware the

accidents which occurred a few days previously at Indianapolis so disheartened the Auto people that they withdrew. We had already spent $1,000 for advertising and had nothing left to show for it.

Our live stock was not required to be on the ground the first week, and those who visited the fair on the first three days found the stalls empty, and word went out that the stock was a failure, whereas, we had a very creditable show when we opened on Monday morning.

We also had a contract with Mr. Savage for Dan Patch and Minor Heir from which we expected great returns but Dan Patch went lame and the attraction was a failure.

We also undoubtedly lost money by the sale of admission tickets in advance at reduced rates. I recommend that this be abolished and that all admission tickets be sold at the regular prices.

I recommend also, that the Fair be held for one week only, beginning promptly on Monday morning at nine o'clock.

The question of passes still bothers us. I wish that free passes might be greatly reduced, and I would even favor the practice of issuing no free passes whatever. If some *must* be issued, let it be done under the most vigorous restrictions.

The grand stand receipts fell off on account of reducing the price of seats from 50 cents to 25 cents and altho the grand stand was well patronized the receipts fell off several thousand dollars.

I would favor one price to all renters of space for lunch and dining halls.

I recommend the engagement of a general manager, who shall devote his whole time to the Fair.

I recommend that the dates of the Fair be made, September 19-23, and that we apply for membership in the grand circuit.

We have reduced our bills payable somewhat and have them concentrated in fewer hands, so that there will be less trouble with them.

We shall soon need more room, and I recommend, that steps be taken to secure a section of land of about 20 acres, lying beteen the grounds and Woodward avenue and north of the D. U. Ry. tracks.

We need more buildings and to secure them in the near future we must raise money by increasing our bonded indebtedness. I recommend that this be increased to two hundred thousand dollars.

We need a number of new buildings, among them, the most urgent are, a machinery or industrial building, an auto or vehicle building, an office building, and a stock amphitheatre.

The "pay" toilet buildings, erected under lease should be purchased under the contract.

We had a successful "horse show" last fair and this should be continued, also the regular horse classes should be shown during the afternoon in front of the grand stand, across the track. To do this successfully a tunnel under the track will be needed, to give free and safe access to the infield.

The infield should be improved, seeded and ornamented.

Another speed barn was erected on the grounds by the Detroit Driving Club advancing the money, and taking the note of the society without interest, payable in 1912 with a 5 per cent discount per annum for the use of the barn under their lease.

Our exhibition horse barn has been used by Detroit horse dealers, who exhibited horses, but who really used it as a sale stable. These persons should not be allowed to use our stalls to the exclusion of others who would fill them with high class horses.

We need more light on the ground to make our evening exhibit more attractive.

Our amusement features were not what they should be. Neither the free attractions, nor the shows. Some of the acts were very commonplace and the shows were bad. I would not allow any shows but those of the highest class.

I desire to thank you one and all, gentlemen, for your uniform courtesy and your effort to work for the interests of the fair. I trust we shall experience the same good feeling in the future.

REPORT OF THE SECRETARY.

The exhibits for 1909 show in total a slight decrease, some departments show a falling off, and others a noticeable increase. Among the latter are the Horticultural and Educational departments. However, in no department was the decrease such as to lessen the quality or value of the exhibit.

The total of cash premiums awarded and paid amounts to $23,280.90. Badges for champion prizes were used in place of medals and cost $80.10. Medals and cups for the stock judging cost $39.50. Cups for grand champion prizes cost $996.00. Total expense for premium awards $24,396.50.

Six hundred and twenty-two membership tickets were sold. It was required that three admission tickets be purchased with each membership. Hence, $1,244.00 was collected from this source. The receipts for stall, pen and poultry fees amounted to $1,608.95.

I concur with the recommendation of the superintendent of cattle, relative to publishing the offers of prizes by breed associations in a separate list from that offered by the Society, and in that of the superintendent of poultry, regarding opening that department to all exhibitors, although I wish to say that he has been misled in the reasons given by him for closing entries in that department in former years to those outside of the state.

Without intending to infringe on the province of the president as to recommendations regarding the Fair, I wish to suggest that membership certificates be not required for the purpose of making entries—indeed, they cannot now well be, since only male persons over 21 years can become members; and that all exhibitors including those who do not receive premiums, but who have space free, be required to procure an exhibitor's ticket, cost $2.00, which ticket shall include one admission each day of the fair to the holder and which shall not be transferable.

I believe that an arrangement should be made whereby stalls and pens may be assigned to exhibitors in order of application, when accompanied by the proper fees, and that such stalls and pens should be retained for such exhibitors unless withdrawn or forfeited by non-arrival at time required by the rules.

I suggest the investigation by a committee to be appointed at the winter meeting of the feasibility of holding a winter fair and exposition, which shall include —without going into details—an exhibit of corn, fruit, dairy products and indeed all food and stock products grown in Michigan.

This should be held in co-operation with the business interests of Detroit, and is in my view a matter worthy of serious consideration.

List of entries in the several classes and divisions. Michigan State Fair of 1909. With amounts offered and awarded in each class.

CATTLE.

Class.	Breed.	No. Entries.	Herds.	Offered.	Award.
1	Short Horns (open to all)	136	45	$814 00	$784 00
1-a.	Short Horns (open to Mich.)	64	19	668 00	577 00
2	Polled Durham	26	10	651 00	307 00
3	Hereford	55	19	848 00	647 00
4	Aberdeen Angus	47	18	651 00	503 00
4-a.	Aberdeen A. Specials	35	(Pd. by Assoc.)		
5	Galloway	37	13	651 00	476 00
6	Jersey	40	8	651 00	435 00
7	Guernsey	17	5	651 00	214 00
8	Holstein-Friesian	72	24	726 00	673 00
9	Ayrshire	28	10	651 00	392 00
10	Red Polled	48	17	651 00	478 00
11	Brown Swiss	18	5	651 00	214 00
12	Dairy Cows	12		100 00	100 00
13	Fat Steers	19		115 00	105 00
		654	193	$8,479 00	$5,905 00

STOCK JUDGING CONTEST.

Twenty young men took part in the Live Stock Judging Contest. The prizes were awarded as follows:

Horses: Lee Hulett, of Lansing..... 88 points
Cattle: S. A. Martin, Pontiac..... 90 points
Sheep: S. A. Martin, Pontiac..... 74 points
Swine: A. B. Winslow, Ann Arbor..... 82 points
Each a Medal.
Champion Cup—Ira Beckley, Battle Creek..... 300 points

HORSES.

14	Standard Bred	33		$489 00	$302 00
15	Non-Standard	28		225 00	190 00
16	Roadsters	46		246 00	241 00
17	Saddle Horses	71		335 00	282 00
18	Carriage and Coach	73		423 00	410 00
19	Runabout	94		505 00	505 00
	Award to Drivers (Class 19)..				56 00
20	Hackney	31		538 00	386 00
21	French Coach	None		538 00	
22	German Coach	None		538 00	
23	American Carriage	15		539 00	218 00
24	Percheron	17		538 00	150 00
25	Clydesdale	17		538 00	257 00
26	English Shire	1		538 00	20 00
27	Belgian	7		538 00	118 00
28	Grade Draft	29		640 00	332 00
29	Shetland Ponies	37		172 00	164 00
30	Jacks and Mules	16		142 00	95 00
		515		$7,491 00	$3,726 00

SHEEP.

31	American Merino	102	14	$242 00	$238 00
32	Delaine Merinos	73	11	242 00	226 00
33	Franco American	33	6	242 00	218 00
34	Rambouillet	74	13	242 00	242 00
35	Lincoln	36	6	242 00	226 00
36	Leicester	39	6	242 00	226 00
37	Cotswold	40	6	242 00	226 00
38	Shropshire	58	10	242 00	236 00
38-a.	Shropshire Specials	3	00	25 00	Paid by Asn.
38-b.	E. S. George Specials.....	10	8	Cup & 55 00	Paid by George
39	Oxford Down	59	8	242 00	228 00
39-a.	Oxford D. Species	8	3	45 00	Paid by Asn.
40	Hampshire Down	46	6	242 00	226 00
41	South Down	19	4	242 00	104 00
42	Horned Dorset	58	10	242 00	236 00
43	Fat Sheep	29		72 00	66 00
		651	111	$3,101 00	$2,704 00

And $125 paid by the Association.

SWINE.

44	Berkshire	75	16	$412 00	$374 00
45	Poland China	60	16	412 00	325 00
46	Essex	37	10	412 00	285 00
47	Hampshire	00		412 00	
48	Small Yorkshire	9	4	418 00	98 00
49	Victoria	21	8	412 00	212 00
50	Chester White	58	20	412 00	382 00
51	Large Yorkshire	16	3	412 00	118 00
52	Duroc Jersey	52	12	412 00	301 00
53	Tamworth	60	12	412 00	346 00
54	Fat Hogs	00		44 00	
		389	101	$4,170 00	$2,441 00

POULTRY.

55 AMERICAN:

Barred Rock	35	
White Rock	16	
Buff Rock	25	
Partridge Rock	7	
Silver Penciled Rock	2	
Columbian Rock	4	
Golden Wyandottes	15	
Silver Wyandottes	7	
Buff Wyandottes	12	
Black Wyandottes	6	
White Wyandottes	30	
Silver P. Wyandottes	2	
Partridge Wyandottes	13	
Columbian Wyandottes	7	
R. C. R. Island Red	12	
S. C. R. Island Red	23	
Buckeyes	13	
Dominiques	13	
White Javas	5	
Mottled Javas	2	
Total	247	
Amount awarded		$270 50

ASIATIC.

Brahmas, light,	14	
Brahmas, dark	5	
Cochin, buff	8	
Cochin, partridge	7	
Cochin, black	7	
Cochin, white	7	
Langsham, black	26	
Langsham, white	11	
Total	85	
Amount awarded		97 50

ENGLISH.

Dorkings, colored	1	
Dorkings, silever gray	10	
Orpingtons, R. C. Buff	8	
Orpingtons, S. C. Buff	47	
Orpingtons, R. C. Black	4	
Orpingtons, S. C. Black	6	

Orpingtons, R. C. White	3	
Orpingtons, S. C. White	15	
Orpingtons, S. C. S.	8	
Orpingtons, S. C. D. J.	4	
Red Cap	7	
Total	147	
Amount awarded		$100 00

FRENCH.

Houdans	12	
Favorelles	7	
Total	19	
Amount awarded		25 00

GAMES.

B. B. Red	10	
Brown Red	5	
Duck Wing Silver	3	
Duck Wing Golden	3	
Red Pyle	5	
White	8	
Black	5	
Birchen	None	
Cornish Indian	12	
White Indian	10	
Black Br. R. M. G.	1	
Total	62	
Amount awarded		66 50

MEDITERRANEAN.

Spanish Black	9	
Minorcas Black R. C.	22	
Minorcas Black S. C.	21	
Minorcas White R. C.	11	
Minorcas White S. C.	7	
Andalusians	14	
Leghorns R. C. White	22	
Leghorns S. C. White	15	
Leghorns R. C. Black	4	
Leghorns S. C. Black	10	
Leghorns R. C. Brown	7	
Leghorns S. C. Brown	16	
Leghorns R. C Buff	6	
Leghorns S. C. Buff	24	
Total	196	
Amount awarded		240 00

HAMBURGS.

Gold Spangled	3	
Silver Spangled	34	
Gold Penciled	8	
Silver Spangled	15	
Black	12	
White	2	
Total	74	
Amount awarded		71 50

POLISH.

White Crested B	24	
White	5	
Golden	16	
Silver	10	
Buff Laced	14	
Gold Bearded	16	
Silver Bearded	8	
Total	93	
Amount awarded		$101 50

GAME BANTAMS.

Black B. Red	6	
Brown Red	3	
Duckwing Silver	5	
Duckwing Golden	7	
Red Pyle	10	
White	4	
Black	1	
Burchen	3	
Cornish Indian	1	
White Indian	1	
Total	41	
Amount awarded		43 00

ORNAMENTAL BANTAMS.

Golden Seabright	15	
Silver Seabright	16	
R. C. White	13	
R. C. Black	17	
White Booted	4	
White Cochin	21	
Buff Cochin	18	
Partridge Cochin	7	
Black Cochin	24	
Light Brahma	6	
Dark Brahma	10	
Black Tailed Jap	17	
White Japanese	7	
Black Japanese	3	
White Crested Polish	5	
Barred Plymouth Rock	3	
Total	186	
Amount awarded		215 00

MISCELLANEOUS.

Sumatra Black	8	
Mottled Anconas	13	
Silkies White	9	
Total	30	
Amount awarded		42 50

TURKEY CLASS.

Bronze	6	
White	11	
Buff	9	
Black	10	
Slate	7	
Narragansett	8	
Total	51	
Amount awarded		$115 00

DUCK CLASS.

Pekin	11	
Rouen	14	
Aylesbury	8	
Indian Runner	14	
White Call	11	
Grey Call	12	
Black India	10	
Cayuga	12	
Crested White	7	
Muscovy, colored	16	
Muscovy, white	4	
Total	116	
Amount awarded		153 00

GOOSE CLASS.

Toulouse	9	
Embden	7	
African	6	
China White	8	
China Black	8	
Buff	7	
Total	45	
Amount awarded		72 00

ORNAMENTAL FOWLS.

Pea Fowls	1	
White Guinea	2	
Pearl Guinea	4	
English Pheasant	1	
Variety	12	
Total	20	
Amount awarded		13 00

PIGEONS.

Dragoons	1	
Fan Tails	5	
Homers	1	
Jacobins	4	
Swallows	2	
Tumblers	1	
Total	14	
Amount awarded		8 25
Belgian Hares	34	
Amount awarded		24 00
Grand total	1,429	
Grand total amount awarded		$1,685 25

AGRICULTURE.

Class.			Offered	Awarded.
56	Grains and Seeds	179	$641 00	$525 00
	Corn	97	308 00	204 50
57	Roots and Vegetables	378	395 25	326 50
	Coll. of Vegetables	30	307 00	248 00
58	County Exhibit	8	400 00	400 00
		692	$2,051 25	$1,704 00

DAIRY.

59	Creamery Butter	54	$103 00	$99 90
	Dairy Butter	10	50 00	49 54
	Cheese	39	174 00	142 56
60	Domestic Mfgs.	44	68 50	52 50
		147	$395 50	$347 50

APIARY.

61	Bees and Honey	32	$230 00	$174 00

ART.

62	Professional	66	$230 00	$93 50
63	Open to all	61	153 50	73 50
64	Amateur	126	257 50	137 50
	Non-enumerated	122		132 50
		375	$641 00	$437 00

NEEDLEWORK.

65	Professional	343	$405 50	$255 50
66	Amateur	370	413 25	226 00
	Non-Enumerated	46		25 25
		769	$818 75	$506 75

HORTICULTURE.

67	County Exhibit	27	$750 00	$640 00
68	Collection and Displays	265	1,232 00	885 00
69	Single Plates:			
	Apples	610	200 25	170 75
	Pears	259	90 00	73 75
	Peaches	232	112 50	104 25
	Plums	221	101 25	91 25
	Grapes	75	65 25	40 00
	Quinces	15	9 00	7 50
70	Dried and Canned Fruits	162	273 25	219 75
71	Plants in Pots	10	379 00	43 00
72	Plants in Beds	21	345 00	162 00
73	Cut Flowers, Professional	25	264 50	90 00
74	Plants in Pots, Amateur	None	29 75	
75	Cut Flowers, Amateur	73	118 50	87 00
	Non-Enumerated	10		75
		2,005	$3,970 25	$2,615 00

EDUCATIONAL.

76	County Normal	98	$228 00	$124 00
77	High School	95	189 00	105 00
78	Grammar	298	231 00	215 00
79	Intermediate	384	204 00	193 00
80	Primary	234	98 00	93 00
	Kindergarten	34	33 00	31 00
81	Manual Training	167	237 00	142 00
82	Village Schools	56	148 00	85 00
83	District Schools	40	252 00	54 00
	Non-Enumerated	11		21 00
		1,417	$1,620 00	$1,063 00

Total entries, 9,480.
Total prizes offered, $34,626.00.
Total prizes awarded in money, $23,280.90.

REPORT OF THE TREASURER 1909.

Mr. President and Gentlemen of the Executive Committee:

I beg leave to submit my annual report as Treasurer of the society for the year 1909.

Balance on hand January 2nd, 1909	$2,108 31
Received for General Admissions	26,716 50
Received for Grand Stand afternoons	8,826 00
Received for Grand Stand evenings	4,566 50
Received from Check Room	346 55
Received from Shows	4,044 39
Received for Garbage Gate	50 50
Received for Fines Collected	10 00
Received for Grand Stand Seats sold by Finance Committee	42 00
Received for Collections by Cashier	28,002 60
Received during the year from Cashier	84,449 97
Total	$159,163 12
Total Vouchers paid during the year	158,521 62
Balance on hand January 2nd, 1910	$641 50

FINANCIAL REPORT.

Receipts for the Year 1909.

Dining hall and lunch concessions	$7,015 00	
Exhibitors' concessions	2,243 15	
Side show concessions	4,119 39	
Miscellaneous concessions	14,871 12	
Total		$28,248 66

General Gate Admission.

Sales at gates	$26,716 50	
Advance sale of tickets in Detroit	18,350 00	
Advance sale of tickets in State	7,092 45	
Concessioners' half-fare tickets	414 25	
White Star Line tickets	147 35	
Detroit Wholesalers' Association tickets	95 48	
Total		52,816 03

Grand Stand Receipts.

Grand Stand—General admission	$9,710 00	
Grand Stand—Reserved	3,874 75	
Total		$13,584 75

Miscellaneous Receipts.

State of Michigan for premiums	$10,000 00	
Memberships	1,242 00	
Race Entry fees	2,402 50	
Catalogue and Premium List advertising	2,845 00	
Miscellaneous race concessions	2,338 00	
Stall rentals and poultry fees	1,609 65	
Check room receipts	347 75	
Stands sold at grounds	32 00	
W. W. Buelow—Deducted from Rockwell concession	43 75	
Advertising envelopes sold	206 00	
Butter sold by Dairy Department	10 90	
John McKay (Garbage Gate)	50 50	
Total		21,028 05

Special Premium.

American Shorthorn Breeders' Association	538 75	
American Hereford Cattle Breeders' Association	152 77	
Holstein Cattle Breeders' Association	75 00	
Total		766 52
Total receipts		$116,444 01

Expenditures for the Year 1909.

Officers' Salaries Paid.

I. H. Butterfield, Secretary	$1,200 00	
John McKay, Treasurer	300 00	
James Slocum—Ass't General Supt., Bookkeeper, Stenographer, Office Rent, etc.	2,500 00	
Total		$4,000 00

Department Expenses.

Treasurer's expenses	$283 95	
Horticultural	420 79	
Needlework	178 88	
Horse	462 67	
Swine	128 10	
Sheep	146 32	
Cattle	270 17	
Apiarian	105 46	
Transportation	139 78	
Poultry	308 60	
Agricultural	223 60	
Educational	180 68	
Dairy	108 90	
Implement and Machinery	119 46	
Art	173 20	
Vehicle	39 40	
Speed	6,396 23	
Executive expense (Expenses of Officers at Annual Meeting and business trips during year)	2,099 16	
Total		11,785 35

Labor During Fair.

Check room	$135 62	
Main building	71 56	
Administration building	45 00	
Ticket sellers and takers (gates)	1,381 20	
Grand stand	260 85	
Labor on shows	932 36	
Nightwatch and police	1,123 06	
Timekeeper	100 00	
Finance Committee	436 63	
Total		$4,486 28

Printing and Advertising Expense.

Billboard advertising	$1,643 80	
Newspaper advertising	7,295 75	
Plates—Circulars and distributors	1,476 30	
Gies and Company—Advertising envelopes	313 82	
F. J. Huntley—Publicity Department	348 14	
Printing and stationery	471 44	
Auto race advertising circulars	73 07	
Ticket expense, printing, etc	481 03	
Interstate Clipping Bureau	40 00	
Sprunk Engraving Company	50 35	
Total		12,193 70

Miscellaneous Accounts Paid.

Insurance	$3,111 13	
Office expense (telephone, telegrams, supplies)	632 98	
Office labor	918 48	
Rent	344 58	
Maintenance of grounds	3,153 63	
Maintenance of buildings	974 40	
Toilet building expense (labor)	126 50	
Diplomas, badges, ribbons, etc	369 41	
General postage	365 00	
Premium on bond of Treasurer	37 50	
Electric lighting expense	600 65	
Interest	8,584 64	
Premiums awarded	23,393 90	
Catalogue and Premium List expense soliciting, postage and express	2,939 59	
Amount due from Detroit Driving Club (rent, telephone, one-half water expense)	438 17	
A. M. Nassau (money given to Guy Miller, attorney)	50 00	
J. C. Goss and Company (tents and awnings)	220 80	
Guy C. Miller, attorney fees	100 00	
Meal tickets for policemen, firemen, employes	119 40	
Detroit Riding School—Horses furnished	73 38	
American Trotting Association—Dues	75 00	
Poultry entry fees returned	1 75	
St. Louis Button Co.—Buttons	37 00	
Detroit Sign Company—Sign painting and decorating	188 25	
Miscellaneous expense	1,205 14	
Total		48,061 28
Special attractions		15,009 19
Total expenditures		$95,535 80

Total receipts	$116,444 01
Total expenditures	95,535 80
Gain	$20,908 21

Cash on hand January 1st, 1909		$1,190 80
Net gain for 1909, as per statement		20,908 21
		$22,099 01
Amount paid by J. O'Hearn—9-28-08—for 1909 concession		5,000 00
		$17,099 01
Amount paid on 1908 account	$3,300 39	
Amount collected on 1908 account	1,716 70	
		1,583 69
		$15,515 32
Paid out for permanent fixtures, implements, furniture and improvements to grounds and buildings		8,268 56
		$7,246 66
Paid out on 1907 account		251 50
		$6,995 16
Amount of indebtedness increased		5,744 33
Balance on hand January 1st, 1910		$250 83

Receipts on 1908 Account.

Hay sold	$30 00	
Detroit Driving Club	500 85	
Detroit Sanitary Co.	15 00	
1908 race concessions	640 20	
Barnes & Silverwood (1906 fines)	25 00	
John McKay	200 00	
1908 catalogue advertising	242 50	
Postal Commission rebate	35 00	
Vouchers cancelled	28 15	
Total		$1,716 70

Disbursements on 1908 Account.

1908 Premium awards paid	$1,000 15	
1908 Cafe services (Griswold, Oriental)	309 35	
1908 Labor account	174 47	
Michigan State Telephone Co.—Setting pole	75 00	
J. J. O'Brien—Rebate on score card concession	56 00	
Chas. F. May—Printing annual statement	74 55	
Merriam, Simons, Yerkes—Legal services	75 00	
Upper Peninsula Claim	300 00	
Noack and Gorenflo	1,217 06	
Miscellaneous expense	18 81	
Total		$3,300 39

Permanent Fixtures and Improvements.

Furniture and fixtures (office furniture, etc.)	$2,272 90	
Tools and fixtures	42 04	
Permanent improvements to buildings	3,974 30	
Permanent improvements to grounds	2,979 42	
Total		$8,268 66

1907 Accounts Paid.

1907 Premiums		$251 50

Speed Department Expense.

Purses	$5,700 00	
Programs	175 00	
Frank Cooke—Race track publicity	200 00	
Horse Review Company advertising	17 48	
Horse World Company advertising	15 00	
Western Horseman advertising	13 22	
American Sportsman advertising	15 00	
Trotter and Pacer advertising	17 70	
Labor advertising	242 83	
Total		$6,396 23

Bills Payable (Notes)—January 1st, 1910.

Detroit Driving Club	$6,742 36
John McKay	500 00
Robert McKay	2,000 00
Romeo Savings Bank	5,000 00
Peoples State Bank	15,000 00
Peoples State Bank	15,000 00
Walker and Company	1,187 36
Home Savings Bank	5,000 00
Jacob Guthard and Sons Company	2,831 11
	$53,260 83
Romeo Savings Bank	5,000 00
Caroline McKay	5,000 00
Citizens National Bank	5,000 00
Total	$68,260 83
Note given for permanent improvement to buildings:	
Detroit Driving Club	3,295 00
Total	$71,555 83

Accounts Receivable.

L. H. Burnett—Cat. and Prem. List Advt.	$15 00
F. B. Hibbler—Cat. and Prem. List Advt.	25 00
M. W. McInnes—Cat. and Prem. List Advt.	45 00
T. Streeter and Co.—Cat and Prem. List Advt.	25 00
McCormick Nursery—Cat. and Prem. List Advt.	15 00
Detroit Driving Club	563 17
G. Gaston, Sheriff	405 00
F. S. Rockwell—Balance on concession	113 25
Geo. P. Yost—Balance on exhibition contract	24 00
Wagner Baking Company—For walk	6 05
John J. Barlum, commissions	
Michigan Sales Co.—Packages checked	1 40
	$1,237 87

There are also rural advance sale admission tickets not paid for, 100 each to Caseville Critic, Turner Tribune and Vicksburg Commercial.

Accounts Payable.

Guy A. Miller—Retainer for year	$50 00
John W. Ladd—Labor, attending cows for milking mach.	13 00
Harley and Atcheson—Architectural services	300 00
Postal-Doherty Auto Co.	12 00
Chas. F. May Co.	75
Stevenson, Butzel & Carpenter, attorneys	250 00
Walker & Son	221 54
	$847 29

REPORT OF TICKET SALES AT FAIR GROUNDS.

Tickets received of John McKay, Treasurer:			
General admissions	60,000	$30,000 00	
Children's admissions	20,000	5,000 00	
Night admissions	18,000	4,500 00	
Grandstand admissions	60,000	15,000 00	
Box seats	13,136	6,568 00	
			$61,068 00
Tickets Returned to Treasurer:			
General admissions	12,765	$6,382 50	
Children's admission	15,664	3,916 00	
Night admission	9,934	2,483 50	
Grandstand general admission	17,132	4,283 00	
Box seats	7,188	3,594 00	
			$20,659 00
Tickets Sold and Paid Treasurer For:			
General admission	47,235	$23,617 50	
Children's admission	4,336	1,084 00	
Night admission	8,066	2,016 50	
Grandstand general admission	42,868	10,717 00	
Box seats	5,348	2,674 00	
Box seats, orders	600	300 00	
			40,409 00
			$61,068 00

Cash Receipts Orders:		
September 2	$504 00	
September 3	1,160 25	
September 4	3,102 50	
September 5	1,062 50	
September 6	12,324 65	
September 7	5,533 35	
September 8	6,639 25	
September 9	8,697 50	
September 10	1,085 00	
	$40,109 00	
Credit box seat orders	300 00	
		40,409 00

(Signed) P. B. ROBINSON.

GRANDSTAND DAILY RECEIPTS.

1909.	Afternoon.	Evening.
September 2	$60 50	$.....
September 3	184 75	.....
September 4	600 50	404 50
September 5	.....	.....
September 6	2,436 76	1,799 00
September 7	1,234 00	706 25
September 8	1,455 25	979 00
September 9	2,666 75	677 75
September 10	187 50	.....
Detroit wholesalers	149 25	
Box seats (extra)	43 00	
	$9,018 25	$4,566 50
Total		$13,584 75

1908 grandstand receipts were—afternoon, $10,863.00, and evening, $7,206.50; total, $18,069.50.

NOTE.—In 1908 the fireworks cost $5,000, and in 1909, $2,000. The general admission to the grandstand in 1908 was 50c and in 1909, 25c.

SPECIAL ATTRACTIONS.

Gregory Fireworks	$2,000 00
Beachey and Knabenshue, Airship	3,500 00
Harold Jarvis, Soloist	250 00
W. C. Morgan, services in Horse Show	100 00
Schmerman Military Band	538 75
Kopps's Band	1,500 00
Frank Spellman's Free Acts	1,258 80
Bert Morphy, Soloist	200 00
Western Vaudeville Association	696 30
Navassar's Ladies Band	1,800 00
Children's Prizes	111 75
Auto Race Cup	13 00
Litchenburg Sons, feed for Herzog horses	18 84
Gertrude Sackett's Chorus of Children	60 00
Dan Patch and Minor Heir Purse	2,000 00
Detroit Motorcycle Club	961 75
	$15,009 19

STATEMENT OF INVESTMENT—LAND, BUILDINGS AND IMPROVEMENTS.

1905.	
Land donated	$61,000 00
Land purchased	10,000 00
Drainage and sewer improvements	3,650 88
Water system	3,400 38
Track	7,777 96
Fence	1,158 72
Grading walks and roads	2,460 03
Electric light plant	6,449 94
Michigan building	18,058 70
Grand stand and seating	55,227 46
Horse barn	31,511 08
Speed barns and other buildings	11,949 35
Main building	31,144 39
Material on hand	1,814 99
	$245,603 88
Additions, 1906:	
5 Cattle Barns, each 28 x 240	
2 Sheep Barns, each 28 x 240	
2 Swine Barns, each 28 x 240	
2 Speed Barns, each 24 x 180	
1 Poultry House, 40 x 150	
1 Agricultural Building, 40 x 150	
1 Dairy Building, 40 x 150	
1 Brick Horticultural Building, 70 x 160	
1 Brick Agricultural Building, 70 x 160	
1 Bleacher, 40 x 160	
1 Dining Room 40 x 100	
1 Band Stand, 32 x 56	
8 Closets, each 15 x 40	
Total cost	83,870 83
	$329,474 71
Addition to Grand Stand	4,124 00
Exit turnstiles	1,128 00
Electric wiring and lamps	11,483 98
Addition to water, sewer and closet	14,254 87
Grading and improving walks and drives	8,275 87
Iron fence at track	1,100 00
Permanent work on track	1,280 47
Material on hand	1,023 50
At close of 1906	$372,145 40

Added, 1907:		
Fire Engine House	$855 83	
To Electric Light System	5,277 96	
Sewer and Water	4,300 19	
Improvements to Buildings	806 79	
Turnstiles	671 09	
Shrubs and Trees	909 30	
Improvement grounds	2,383 22	
Transformer House	88 00	
Tracks for freight	1,773 66	
		$17,066 04
Added, 1908:		
Iron Fence at Track	$573 40	
Cement Walk and Area	4,831 29	
Septic Tank	1,233 12	
Water Tank	250 00	
Walks and Drives	461 99	
Track Improvements	7,041 19	
Speed Stables and Judges' Stands	9,039 28	
		23,430 27
		$412,642 71
Added, 1909:		
Cement Walk, 25,000 sq. ft.	$1,450 00	
Improvement, Poultry House	100 00	
Improvement to Grand Stand and other buildings	731 15	
Speed Barn	3,668 00	
Improvements to Electric Plant	1,525 00	
Improvement to walks, drives and grounds	1,423 37	
Land purchased of Jas. Dwyer	575 00	
		9,472 52
Grand Total, Real Estate		$422,115 23
Personal property, tools, implements, team, furniture, etc., valued at		4,000 00
Grand Total		$426,115 23

REPORTS OF EXECUTIVE SUPERINTENDENTS.

CATTLE DEPARTMENT.

To the President and Members of the Executive Committee:

Gentlemen— Your Superintendent of Cattle begs leave to offer the following report. The cattle show at the Michigan State Fair in 1909 was one long to be remembered. While not quite equal in numbers to that of 1907, it exceeded that of 1908 both as to quality and numbers. All of the several breeds in which classes are made were represented, although some of the valuable ones, notably the Brown Swiss and Guernseys were on hand with but single herds each, which is to be deplored. I would in this connection suggest to the advocates of these two really useful and valuable breeds, that if they hope to retain a classification equal to that offered the other breeds that they must bestir themselves to bring out a creditable showing. I find no fault with the quality of those shown, but I do take exceptions to the limited exhibits. A matter worthy of notice and one that I am unable to account for is the fact that while Michigan is essentially a dairy cattle state and her dairy interests are assuming proportions that would not have been dreamed of by the most sanguine romancer a few years ago, the beef breeds vastly out numbered the dairy breeds in numbers of exhibits at this year's fair. With the liberal classification offered and the intense interest of the dairy traffic it seems to me that the dairymen of the state should bring out a greater exhibit as a business proposition if they have not the fair at heart. The showing of the several beef breeds were noteworthy for a Michigan fair, and it is a matter of no small importance to note that the Champion and Grand Champion Bull

in the open shorthorn class went to a bull that was bred and raised in the state of Michigan by a Michigan man, thus refuting in my opinion the possible argument of a need of a closed class. Here I wish to make a suggestion. I believe it is not to the best interests of the live stock show at the Michigan State Fair to make a double classification offering State Fair money. It is a breeder of discontent and dissatisfaction beyond any other policy. I would make as liberal a classification as were possible, make it to all breeds exactly alike, and make it open to the world to bring the best they have to offer. The Michigan cattle raisers have demonstrated time and time again that they can compete with the world and walk off with the honors. If any of the breeders associations desire to offer specials, we are glad to accept it and for their money they should, of course, be allowed and requested to make such rules and regulations as they desire, but put their money in a separate class if they wish it and have it clearly understood that it is breeders' association money and that the Fair association treats all breeds alike and with an open liberality. This will not meet the approval of every breeder, but I am confident that it is the best all-around policy. I do not think there is an association—a breeders' association, I mean—in the land that will assume to dictate what the Fair shall do with their money as a condition of special money being offered. There is little doubt in my mind but what it was a serious mistake to hold the stock show a less number of days than the rest of the fair. People would come through the barns the first days of the fair, see no stock and go home and say the fair was a fizzle. They did not understand the situation. It is my firm conviction that the stock should be there as many days as admission is charged at the gate. The forage management this year seemed to be as good as it is possible to make it. I heard absolutely no complaints as to charges or service. All in all, I think the cattle show a creditable one, indeed, the Michigan State Fair a hummer, and am sure that if we will all work in harness with a single purpose—that of the best fair on earth—in view, that it will grow better year by year. All of which is respectfully submitted.

C. A. TYLER, Superintendent.

HORSE DEPARTMENT.

To the President and Members of the Executive Committee:

Gentlemen—As acting Superintendent of the Horse Department at your society's fair in 1909, I beg leave to submit the following report:

The horse exhibit at the State Fair last fall was in my opinion better than the preceding year. The number of entries was 515, but as many of the entries were for special classes which were shown in the evening, they did not occupy stalls. The exhibit of light horses was exceptionally well filled and comprised some of the best horses I have ever seen. There were a fair number of entries in the Percheron and Clydesdale classes, but the competition was not as good as it should be, one exhibitor filling several classes. Owing to the enforcement of the rule requiring the horses to be on the ground at a certain time, about 20 Percheron horses were barred. There were no entries to speak of in the German coach, French coach and Belgium classes. The exhibits in the pony classes were very fine, but one exhibitor owned the majority of them. There were only two exhibitors of jacks and mules and really no competition.

The exhibiting and judging of horses in the evening, known as the horse show, attracted a great deal of attention and to my mind should be continued. There were only three men employed in the department outside of myself except during five evenings, when two laborers were employed to assist in the judging ring. Two of the men employed were obliged to work from early in the morning until after the horse show in the evening and should receive more compensation than the man who works simply during the day. The demand for box stalls is greater than the supply, and, owing to the fact that we were unable to furnish sufficient box stalls, powerful horses were put into single stalls which resulted in some slight destruction. I desire to make the following recommendations:

1. That more box stalls be built so as to accommodate the demand.

2. That all horses exhibiting be required to be on the ground on or before the first day for which admission is charged to the fair. (This recommendation is made for the reason that last year's horses were not required to be on the ground until the 6th day of September, while the fair opened and admission was charged on the 2nd of September and many people on the 2nd, 3rd and 4th came to the barn to see the exhibit of horses and, not knowing the rule, un-

doubtedly went away with the impression that the exhibit of horses was very poor.)

3. That jacks and mules be stricken from the premium list.

4. That the horse exhibit in the evening be continued and enlarged upon and that the premium list as sent out, designate what horses shall be exhibited at night.

5. That an office for the superintendent be built at the southwest corner of the west building.

I feel that I should not conclude my report without stating that the judges were thoroughly competent in every way and little or no fault was found with their judgment. I also feel that Mr. Morgan, who assisted in arranging the program for the night show, is deserving of much credit.

Respectfully submitted,
SHERMAN T. HANDY.

SHEEP DEPARTMENT.

To the President and Members of the Executive Committee:

Gentlemen—The show of sheep at the Fair of 1909 compared very favorably with those of former years. Although in some years there have been more sheep shown, there were enough this year to more than fill the pens, and considerable additional room had to be provided.

Until more barns can be erected, some restriction should be placed on bringing sale sheep to fill pens badly needed for show sheep.

The total entries in this department were 762, and awards $2,704.00 by the Society and $125.00 by associations.

All breeds were fairly represented and the quality was superior.

Respectfully submitted,
W. E. BOYDEN,
Superintendent.

Bay City, Oct. 20, 1909.

SWINE DEPARTMENT.

To the President and Members of the Executive Committee:

Gentlemen—As Superintendent of Swine, I beg leave to make the following report:

The number of entries and amounts awarded are shown in the report of the Secretary.

The expense of judging was $60.00. The judging by Mr. J. M. Linson, of Ohio, was very satisfactory and the exhibitors presented a petition for his employment at the next fair.

Respectfully submitted,
GEO. KELLY,
Superintendent.

SPEED DEPARTMENT.

To the President and Members of the Executive Committee:

Gentlemen—I am pleased to report a very successful year for the Speed Department. Judge Merrill, the starter, gave excellent satisfaction, and the judges, timers and marshal all did good work.

Fifteen races were scheduled, each with $500 purses, making a total offered of $7,500.00. The free-for-all trot did not fill and third and fourth money was not earned in the 2:12 trot, leaving $6,875.00 amount of purses paid.

FINANCIAL STATEMENT.

Receipts.

Ninety-five entries ($15.00 only paid on one entry)	$2,335 00
Four time records	35 00
Per cent from 54 winners	1,350 00
Total	$3,750 00
Pool privilege, net	2,338 00
Score card, net	420 00
One-half afternoon receipts, grand stand	4,509 12
Grand total receipts	$11,017 12

Expenditures.

Paid purses	$6,875 00
Membership American Trotting Association	75 00
Membership Mich. T. & P. Circuit	5 00
Starting judge	125 00
Other judges and timers	25 00
John Carmody	65 00
Palmer helper	12 00
John Thompson, Marshal	25 00
Frank Cook, Publicity	200 00
Programs and list of entries	69 00
Geo. S. Ward, clerk of course, services and expenses	148 83
Advertising	139 04
Entry blanks	9 00
Badges	10 00
Postage	20 00
Superintendent's expenses	100 00
Care of track during fair	225 00
	$8,122 87
Net amount to credit of Speed Department	$2,894 25

E. FIFIELD, Superintendent.

POULTRY DEPARTMENT.

To the President and Members of the Executive Committee:

Gentlemen—In making my annual report as Superintendent of the Poultry Department of the biggest and best State Fair in America (not sustained by large state appropriations), I shall not hesitate to praise the things worthy of praise nor to condemn the matters pertaining to the department which seem to me to be improper.

In retiring from official connection with the Society, I wish to express the hope that at no time will the future managers of the Fair overlook the fact that the poultry industry of this nation is scarcely second to any pertaining to agriculture, and none enters more completely into home economics. We are assured by highest authority that *one million dollars* per day for every day in the year represents the earnings of the American barnyard fowl, and that the life of every person is sustained in part by this farm product. The subject, then, is not trival, or one to be at any time neglected or lightly considered.

Thirty-four persons and firms made 1,460 entries, and a total of $1,658.75 was paid them in premiums. Detailed list of entries and awards will be found in the report of the Secretary.

As some of those entries were for pairs or pens, the total of living things entered and cared for in the department was 1,819, actual count. The number of entries made by each person, or firm, took a wide range, from one to more than 300. The exhibitors came from the following nine counties of the state, viz.: Genesee, 1; Hillsdale, 3; Jackson, 1; Lenawee, 1; Montcalm, 1; Oakland, 3; Saginaw, 1; Washtenaw, 3; Wayne, 19.

The expense of conducting the department was substantially as follows: Assistant Superintendent and three helpers, $113.00; Judges and one helper, $66.00; feed and litter, $100.00. Besides these expenditures there were some small items for rent of tent for water fowl, and some slight repairs to buildings, coops, etc. Total expense of department, $308.60. Against this are the receipts for entry fees amounting to $362.45.

Only one policy of the State Fair pertaining to the Poultry Department seems to need serious condemnation. It is this: Under present rules, none but Michiganders may exhibit poultry. It is said that this rule was enacted at the earnest behest of some fanciers living, for the most part, in or near Detroit; though the name of this association seems much broader. Be this as it may, no other big state fair has such a narrow-between-the-eyes policy. I am very glad that such a hoggish rule does not exist in any of the other "live stock" departments—not even in the hog department. Besides being wrong in principle it is an active agency of injury to the Fair itself.

Michigan breeders and fanciers who do not live in the southeast corner of the state refused to enter fowl "because it is not a State Fair, but merely a District Fair, and the honor of winning, or the excuse for losing, is not sufficiently great to warrant the expense of making the show." And again: "It is an honor to win in a show open to the world and no disgrace to be defeated in such a show."

Our Fair came near losing its best pony exhibit this year because the owner could not also exhibit his poultry here—some of the best in America. How many breeders of live stock actually stayed away and went to other states because Michigan would not permit them to exhibit poultry cannot, of course, be known; but doubtless some, and perhaps many.

Visitors to a fair go to see or buy the best, not of Michigan alone, but all the open world can or will assemble in Michigan. They certainly pay the price of attending a whole show, only to find the poultry division limited and empty coops occupying space which should be filled with the best products of other states. Many harsh accusations, hard to satisfactorily answer or explain away, have been made against this feature of our Fair.

I am satisfied a bench show would not only instruct, amuse and accommodate many, but could be made a paying institution for the Fair. Many inquiries were made for incubators and brooders. As none were on exhibition much disappointment was occasioned. Certainly manufacturers and agents of such needful appliances lost a grand opportunity to reap a golden harvest.

I earnestly recommend the establishment of "*happy family*" features within a wire-screened inclosure, containing a pool or lagoon, outside the poultry building, and within which shall be assembled numerous specimens of the feathered tribe, of the most beautiful plumage and form obtainable.

I am pleased to quote from the Breeders' Gazette report of the Illinois State Fair upon this subject as follows: "John A. Wheeler exhibited numerous species of game birds—geese, turkeys, ducks, pheasants, cranes, quail, prairie chickens, and the like—in an inclosure which included a small lagoon. No feature of the fair caught or pleased so many eyes as this. Beautiful plumage and the quack and capers of the ducks and the honk of the wild geese were its principal drawing cards."

Such an outdoor inclosure would cost but little and afford breeders an opportunity to exhibit swans and other beautiful water fowl, gorgeously plumaged pheasants, pea fowl, etc., etc., which at present cannot be properly accommodated and hence remain away.

With such a feature added to the Poultry and Pet Stock Department, the silly scenes and songs of the "Midway" would cease to lure, and the "Happy Family Lot" would draw, hold, instruct and amuse Michigan fairgoers as it does in Illinois and other places where introduced. I think Michigan should keep up with the procession of other states and at the same time relieve itself from accusations to which I have referred.

I recommend the extension of the premium list in the goose class to include goslings, or young birds, as well as old. In other words, put geese and goslings on the same basis as hens and chickens.

I recommend that the use of shavings for litter in the coops be discontinued, as the fowl must be fed in the litter and the indigestible shavings will be more or less swallowed with the food and serious loss may result. Short cut straw should be substituted for shavings as a litter.

The liberal and intelligent use of "Kreso" as a disinfectant kept the building entirely free at all times from unpleasant odors. No show should be held without it.

The work of the Judge was highly satisfactory to patrons. I doubt if any judge could have given better satisfaction. Not a single complaint was lodged. My assistant superintendent and the three men employed to assist in the care of exhibits were as prompt, painstaking, gentlemanly and efficient as could be chosen, and to them belong the credit and honor of fully satisfying and greatly pleasing both the exhibitors and visitors of this most successful show.

All of which is respectfully submitted.

L. C. HOLDEN, Supt. of Poultry.

Sault Ste. Marie, Mich., September 30, 1909.

DEPARTMENT OF AGRICULTURAL PRODUCTS, SEEDS, GRAINS AND VEGETABLES.

To the President and Members of the Executive Committee:

Gentlemen—The exhibit of grains, seeds and vegetables at the fair of 1909 was of a high order. The entries numbered a total of 692 and the awards amounted to $1,704.00.

Eight county displays were made. This feature of the list seems to be popular and brings out fine displays.

Lack of space and the division of the exhibit in separate buildings creates a disadvantage in arrangement and display of exhibits that makes it impossible to secure the best results.

I sincerely trust that in 1910 this department may be housed in the brick building intended for it, where there will be opportunity to put up the exhibits in good form.

I regard the display of farm crops as one of the leading features of the fair and worthy of the greatest encouragement. Second in value only to live stock, and when properly displayed second to none in attractiveness.

I have a few suggestions for the premium list which I will make to the premium list committee.

The formation of two associations of northern counties for the purpose of promoting the development of that section of the state may make it necessary to change the terms of the premium offers heretofore made for county exhibits.

If the associations shall undertake the work that has been done by counties and make the exhibits at fairs, the premium list will need to be changed.

There was no exhibit from the Upper Peninsula at the last fair. This is to be regretted, as the large agricultural resources of that section should be represented. Some steps should be taken to bring the U. P. in closer touch with the fair.

The exhibit of corn grown in 1908, as made by arrangement with the Michigan Corn Improvement Association, was not as large as was expected. The early dates of the fair preclude a good exhibit of corn grown the year of the fair, and some means should be adopted to secure an exhibit of the year previous that would be worthy the state and of the most valuable crop grown in the state.

The boxes and crocks procured, in which to show exhibits of grains and potatoes proved very satisfactory and as many more are needed to show all exhibits.

Respectfully submitted,

W. J. TERNEY, Superintendent.

APIARY DEPARTMENT.

Caro, Mich., December 15, 1909.

To the President and Members of the Executive Committee:

Gentlemen—In submitting my annual report as Superintendent of the Apiarian Department I wish to say that, while we did not have a great number of individual exhibitors, we did have as fine a display of apiarian products, together with implements and bee-keepers' supplies, that was ever exhibited at any State Fair, and if the location now used for such display could be inclosed with glass and ceiled inside, it would be acceptable to exhibitors as a permanent location, and I would earnestly recommend that such improvements be made. As the bee-keepers in Michigan are quite numerous and still growing, and as they seem to be taking quite an interest in the bee industry (as the crowds of interested people who visited our display would indicate), great praise should be given Mr. C. M. Nichols and others who made such a fine display in 1909.

Very respectfully,

F. B. RANSFORD,
Superintendent.

VEHICLE DEPARTMENT.

Carleton, Mich., November 27, 1909.

To the President and Members of the Executive Committee:

Gentlemen—I am pleased to note there was a gain, if but a small one, in the number of exhibitors in the Vehicle Department. Last year there were, fourteen, while this year we had seventeen, the gain being made by more automobile exhibitors. Following is a list of the exhibitors: Anderson Carriage Co., Cadillac Motor Co., Regal Motor Co., Ford Motor Co., Maxwell, Briscoe & McLeod Auto Co.,

Brush Motor Co., Clarke Motor Co., J. B. McIntosh, Economy Auto Garage Co., Lansing Wagon Works, Columbia Carriage Co., Brown & Sehler Carriage Co., Pontiac Buggy Co., Durant & Dort Buggy Co., Flint Carriage Co., Fuller Carriage Co., Prouty & Glass Carriage Co.

I believe the time is not far distant when it will be necessary for you to erect a building for this department, as well as for implements and machinery. There were complaints among many of the great trouble in erecting tents and placing their displays, to say nothing of the risk of damage to their goods. This year, however, we were very fortunate in having good weather. In conversing with exhibitors, I found many who expressed themselves as being willing to pay a good rental could they be in a building. This would be a good investment for the Society and a special attraction for the visitors. Michigan being the automobile center of the world, this great industry should have a suitable building for its exhibits at the Michigan State Fair.

While I am to sever my connection this year with the Society as an officer, I shall always feel interested in its welfare.

Respectfully submitted,
CHAS. L. EDWARDS,
Superintendent Vehicle Department.

IMPLEMENT AND MACHINERY DEPT.

To the President and Members of the Executive Committee:

Gentlemen—Permit me to submit to you the following report of the Department of Implements and Machinery for the sixteenth annual State Fair of Michigan, held at Detroit Sept. 2-10, inclusive, 1909.

There were one hundred thirteen (113) exhibits in this department of our Fair of 1909 as compared with one hundred twenty (120) at the Fair of 1908. This falling off in the number of exhibits is mainly due to the fact that the manufacturers of threshers, engines and other similar classes of the so-called heavy machinery had entered into an agreement not to exhibit at any state fair during the year 1909. The total expense for conducting this department for the entire year was $119.46, as shown by my statement rendered to Secretary Butterfield under date of September 25, 1909.

Assuring you of my earnest endeavors in the future to make this department of our Fair worthy of inspection in every detail, I am,

Respectfully yours,
VINCENT V. GREEN,
Superintendent Implements and Machinery.

ART DEPARTMENT.

To the President and Members of the Executive Committee:

In making a statement of the Art Department of the State Fair for 1909, I beg to say that under the present circumstances, taking into consideration the building now used for the art exhibit, there is not much to report.

The exhibition the past year was far above the average in merit, though below the number of entries usually made. This is largely due to the fact that I have discouraged those people who think they can draw and paint without preliminary training, and who lack the faculty of learning from others for the reason that they think themselves a born genius. On the other hand, I make every effort to encourage where there is real merit.

In the present building, with doors and windows on every side, the light for a picture is so unfavorable that but few really good artists care to exhibit. Then, too, the building is too unsafe to ask the owners of works of art for a loan. Thus we cannot expect the Art Department under present conditions to attract very much attention or be of much value to the visitors.

I again urge, as I have in the past, that the Society erect a plain one-story brick building, with a cement floor and iron roof, with skylight properly arranged for the hanging and exhibition of pictures. Such a building need not cost a great sum, and as it would be practically fireproof and properly lighted we could then ask for the best things in art, and make this department of such interest that it would attract visitors from all over this and near-by states. In fact it could be made one of the chief attractions of the Fair, and would pay.

I would most urgently request that you give the question of a new art building the most serious consideration.

Respectfully,
A. H. GRIFFITH,
Superintendent.

NEEDLEWORK DEPARTMENT.

To the President and Members of the Executive Committee:

Gentlemen—It gives me much pleasure to state that the exhibition of needlework at the Fair of 1909 was an advance on that of previous years; and although the entries were not as numerous as last year, yet the class of work was much better. The number of entries this year was 769; the total amount of premiums awarded was $506.75.

The dropping off of entries I think was due to the $2.00 rate for membership and entry fee, thus practically barring out the small exhibitor. I would suggest that there be a class in this department for children's work with a rate to exhibit that would not be prohibitive. We would have had an increase in number of entries had there been a special class for children's work. The entire expense of the superintendent, including railroad fare, postage, per diem, etc., were $58.10. Our space was thronged with interested visitors each and every day during the entire Fair, thus showing that this department should receive your continued encouragement.

Wishing to thank the officials of the Society for their kind and courteous treatment, this report is respectfully submitted.

BELLE F. CLARK,
Superintendent Needlework.

HORTICULTURE DEPARTMENT.

To the President and Members of the Executive Committee:

The exhibition space in the Horticultural Building was completely filled and the quality of the exhibits was commended by everyone. So far as I have learned, the exhibitors and visitors were well pleased with the horticulture section of the Fair, and with the awards that were made.

Among the new features was the substitution of green lattice work in the form of arches and covered with southern smilax for the bunting which has been used heretofore for decorating the interior of the building. The effect was quite pleasing, as it harmonized with the greenhouse plants which were used as a decoration, besides having a restful appearance.

Believing from the exhibits in previous years that more fruit would be shown than could be properly displayed, no effort was made to secure exhibits. This was very fortunate, as the amount presented was all that could be cared for and many of the tables were crowded too much to give the best effect.

Fruit was on exhibition from twenty-five counties and most of them made a county display. A sweepstake cup for the best county exhibit of fruit was offered for the first time. This was awarded to the exhibit from Oceana county, which for a number of years has been given first place. There were many other fine exhibits from other counties, especially from Allegan, Berrien, Washtenaw, Lapeer and Bay in the southern half of the state, while those from Grand Traverse, Emmet, Clare, Roscommon and other northern counties demonstrated the wonderful possibilities, in horticultural lines, possessed by the section.

The classes for general and special collections and for single plates of the different varieties of fruit were also well filled. The great drawback to making a satisfactory exhibit of horticultural products comes from the fact that owing to the early date at which the fair is held the winter varieties of fruit have reached but little more than one-half their full size and in most cases do not show their color or markings. This is especially unsatisfactory to those who wish to study the different varieties, as they are not able to get a correct idea of the late fall and winter sorts. It also gives to visitors an erroneous idea of the character of Michigan fruit. Partly to correct these difficulties and also to aid in brightening up the exhibit, it is recommended that a separate schedule of premiums be offered for fruit of the previous year which has been carried in cold storage. These should include premiums for fruit put up as displays, in collections and as single plates, but as it need only include a few of the more desirable winter varieties of apples, it would not add materially to the amount of the premium list, and in the ways mentioned it would greatly improve the appearance and educational features of the exhibit.

The canned fruit as usual made a fine appearance, although owing to the dropping out of one of the exhibitors who has in previous years taken her full share of the premiums, the number of entries was slightly smaller than in 1908.

The exhibits of plants and cut flowers were about the same in extent as in previous years, and there was a slight increase in the exhibits of bedding plants, all of which helped to embellish the building and growths. The exhibits by several of the leading nurseries of ornamental trees and shrubs, upon a space set aside for the purpose near the Michigan building, helped to decorate that section of the ground and proved of much interest to visitors.

The judging of the pomological exhibits was done by T. A. Farrand, of Eaton Rapids, and F. A. Wilken, of South Haven. Dr. E. H. Hayward, of Detroit, passed upon the fruit exhibits, and Frank Holznagle, of Highland Park, and Thomas Gunson, of East Lansing, judged the plants and flowers.

As for a number of years, Mrs. S. R. Hoffman, of Detroit, has proved of great assistance by taking charge of and arranging the exhibit of canned fruit, while Miss Vesta C. Haney has looked after the arrangement and care of the plants and cut flowers.

The horticulture building is admirably adapted for displaying fruit, plants and flowers, and we now have as many plates and vases as are likely to be needed, or at least as many as can be used to good advantage without crowding the tables. I would, however, favor more attention to "displays" of fruit, for the purpose of setting off the tables, and trust that the exhibitors will take the matter up. While especial attention should be given to exhibiting fruit upon plates, it would seem desirable in view of the introduction of the bushel and other boxes for the marketing of select fruit, to offer some inducements that will bring out a large display of fruit in boxes. This is the way in which most of the fruit is shown at the fruit shows in the western states as well as in Ontario, and if this can be brought about it will not only add to the appearance of the horticulture exhibit, but it will serve to draw attention to the advantages of this method of marketing fancy fruit and at the same time furnish object lessons in the grading and packing of fruit.

Respectfully submitted,
L. R. TAFT, Supt. of Horticulture.

East Lansing, Michigan, December 14, 1909.

EDUCATIONAL DEPARTMENT.

Jackson, Mich., December 4, 1909.

To the President and Members of the Executive Committee:

Gentlemen—It gives me much pleasure to submit the following report of the Educational Department of the State Fair, held at Detroit, September 2-10, 1909:

The Educational Department is far beyond the experimental stage. The year 1909 was by far the largest in the history of the department.

The quality of the work was the best ever produced in Michigan, considering the size of the exhibit. Many of the largest school systems making most creditable showing in drawing and manual training.

The number of schools exhibiting this year was increased by 20% over last year.

The best exhibit of manual training came from Houghton, Mich.

This year the county normals were interested for the first time.

This premium list was arranged for County Normals, High Schools, Grammar Grades, Intermediate Grades, Primary Grades, Manual Training, Village Schools and District Schools.

This being the second year for the Educational Exhibit in its new quarters, it was well systematized in regard to space.

In all of the different classes the entries were good and made a fine exhibit.

Awards of prizes were made as follows, for the different departments:

County Normal Classes	$129 00
High School Classes	117 00
Grammar School Classes	218 00
Intermediate Classes	193 00
Primary Classes	83 00
Kindergarten Classes	41 00
Manual Training Classes	142 00
Village School Classes	85 00
District Schools	54 00

Making a total of $1,062 in premiums paid by the Society for exhibits in the Educational Department.

The work in music for all grades showed a marked advance over previous years.

In making a comparison for the years 1907, 1908, 1909. In 1907 we had a showing of 875 entries and paid $962.00 in premiums. In 1908 we had a showing of 1,143 entries and paid $914.00. In 1909 we had a showing of 1,587 entries and paid $1,062, making an excellent increase in entries without a small increase in premium paid.

Respectfully submitted,

THOS. M. SATTLER, Supt. of Educational Department.

To the President and Members of the Executive Committee:

Gentlemen—In accordance with rule six of said society, I submit the following as my report for my department for the year 1909: The number and quality of the exhibits in this department were fine and complete, exceeding that of former years. We labored under some difficulties which are known to the business committee and I think will be remedied next year. The amount realized for space was cared for by the business committee, and I presume their report will show the matter in detail. The help I had looking after the building was T. McGarry, who worked seven nights, and Rudolph Papst, Jr., who worked nine days and four nights. I also had two men on September 2, 1909, from 9 a. m. to 12 o'clock M., names unknown, to help clear up. The report of business committee will show the amount paid.

I would recommend that when contracts for space are made in the future that it be distinctly understood that the building will be closed at 7:30 o'clock p. m. sharp. It will be satisfactory to the parties exhibiting and I think to the public generally, except those who are selling souvenirs, and they will not suffer. It will save the Society considerable and avoid chances for pilfering the people with valuable exhibits. I think it is a hardship for them to be compelled to stay late at night to watch their exhibits.

I would further recommend that the Society prepare a place to store boxes and packing crates and have the party in charge of the grounds take care of the same for exhibitors, check them and return them when wanted, charging enough for the same to make the Society safe. This would be a great accommodation to exhibitors.

All of which is respectfully submitted.

WM. DAWSON, Supt. Main Building.

TRANSPORTATION DEPARTMENT.

To the President and Executive Committee:

Gentlemen—I beg herewith to submit my report as Superintendent of Transportation, and in doing so, I feel that this department is one which is very important in connection with our fair, and one which will have a great deal to do with the good feeling of our exhibitors.

In the first place, I sent a letter to each exhibitor, asking what, if any, assistance this department could be to him, and requesting the exhibitor to notify me when he would be shipping, over what road, etc., and I assured the exhibitors that we would do everything possible to assure prompt arrival of shipments. Upon sending out these letters, I received from some exhibitors some very complimentary letters, saying that it was evident that the Michigan State Fair was doing all in its power to assist the exhibitors. I recommend that this practice be continued in the future.

The rules and regulations of the railway companies required that all live stock which was shipped to the different fairs, in order to be returned home free, after being shipped on to other fairs, must be returned home over the same roads over which it had been sent to the first fair, even though it might be at a point within fifty miles from home and had been shipped as far as one hundred miles to go to the fairs. This proved a hardship.

In connection with other fairs of the state, I took this matter up with the Michigan Freight Association and they adopted a new rule, whereby exhibitors would only be required to pay one-half the rate and could ship home from the last place of exhibition by the nearest routes. The exhibitors seemed to be very much pleased with this ruling and I feel that the railroads have taken a great step to assist the live stock exhibitors and one which the latter appreciate fully.

The officers of the different railway companies and their agents in Detroit were very kind and courteous and did everything possible to help the fair. The Grand Trunk, upon whom we depended entirely for switching at the fair grounds, was very prompt, courteous and obliging and seemed most willing and anxious to do everything to aid the exhibitors and the fair. Mr. Larry Nolan, of the Grand Trunk, who had charge of the handling of cars and the switching, was on duty night and day, and worked hand in hand with this department. We feel under special obligations to the officers of the Grand Trunk, and particularly to Mr. Nolan. Mr. David Gardner, of the Grand Trunk, who had charge of the clerical staff of the Grand Trunk on the fair grounds, was most obliging. I feel that the kindness of the officers of the Grand Trunk had much to do with the good feeling of the exhibitors this year.

Especial arrangement was made so that the live stock could be loaded out Friday night at the close of the fair, and it was handled promptly and good service was rendered. The machinery followed the next morning. Thus, all shipments were attended to carefully and in a most systematic manner.

Respectfully submitted,
A. E. STEVENSON, Supt. Transportation.

The several reports were accepted and referred to the proper committees. On motion adjourned Sine Die.

The members of the Executive Committee for 1910 were called to order by the President.

Roll called and the following members were present: Postal, Newton, Butterfield, McKay, Marston, Peek, Stevenson, Tyler, Dawson, Green, Kelly, Lessiter, Doherty, Aitken, Terney, Ransford, Taft, O'Keefe, Bowen, Handy, Fifield.

Quorum present.

Mr. Stevenson moved that the dates of the next Fair be Sept. 5-9, 1910. After discussion the motion was withdrawn. Mr. Marston moved, that: All animals shown for premiums shall remain unblanketed from 9 o'clock a. m. to 5 o'clock p. m. during the Fair; that infraction of this rule shall forfeit the awards of premiums made to such animals. Motion carried.

On motion of Mr. Doherty, adjourned to Tuesday, January 11th, at ten o'clock a. m.

Tuesday, January 11th, Executive Committee met at ten o'clock a. m. as per adjournment. Roll called, present: Postal, Newton, Butterfield, McKay, Marston, Peek, Stevenson, Tyler, Whelan, Dawson, Green, Snell, Kelly, Lessiter, Doherty, Aitken, Ransford, Taft, O'Keefe, Handy, Dickinson, Fifield.

Mr. Ransford moved that no adult admission tickets to the next Fair be sold at reduced rate. Carried.

A bill of John O. Lacey for $10.00 for services in the poultry department at the Fair of 1909, and approved by the Superintendent, was allowed.

Mr. Aitken moved that if a grand circuit meeting can be arranged for the week of Sept. 19-23, that the Fair be held on that week, but if not that the Fair be held on the week of Sept. 5-9. Motion carried.

A bill of Harley & Atcheson for $300.00 covering services for drawing plans and specifications for an Administration building, was presented. On motion of Mr. Doherty, Messrs. Dickinson and O'Keefe were appointed a committee to confer with Harley & Atcheson and recommend a basis of settlement and report at the afternoon meeting.

The Secretary was ordered to draw checks for the payment of expenses of members at this meeting. Mr. Aitken moved that the Business Committee and the Finance Committee acting jointly select some person who shall issue complimentary tickets and free passes, and that he shall be instructed to issue no free passes except to persons who shall have done some service to the Society Motion carried.

On motion of Mr. Dickinson, supported by Mr. Aitken, the following resolutions were adopted.

Resolved, That two hundred thousand dollars ($200,000) face value of first mortgage bonds be issued by the Michigan State Agricultural Society for the purpose of refunding one hundred thousand dollars ($100,000.00) of first mortgage bonds already issued and for cancelling one hundred thousand dollars ($100,000.00) of second mortgage bonds issued but not sold.

After providing for the purchase of the one hundred thousand dollars ($100,000.00) of first mortgage bonds, the balance, secured from the sale of the

two hundred thousand dollars ($200,000.00) of bonds authorized by this resolution, to be used in the purchase of real estate, and the erection of buildings on the fair grounds of the Society.

The bonds authorized to be issued under this resolution to become due and payable January 1st, 1920, and to draw not to exceed 6% (six per cent) interest payable semi-annually on the first day of January and July of each year.

Resolved, That the President and Secretary of this Society are hereby authorized to execute a mortgage on all the property of this Society, both personal and real estate, to secure the payment of said issue.

Resolved, That the Business and Finance Committees of this society, on negotiating the bonds authorized by these resolutions, be directed to cancel all bonds heretofore issued under the first and second mortgages now in force.

The roll was called on the adoption of these resolutions with the following result: Yea, Messrs. Postal, Marston, Newton, Butterfield, McKay, Peek, Stevenson, Tyler, Whelan, Dawson, Green, Snell, Kelly, Lessiter, Doherty, Aitken, Terney, Ransford, Taft, O'Keefe, Handy, Dickinson, Fifield. Absent, Messrs. Collier, Bowen, Palmer, Rich, Howland. Yeas, 23. Nays, None. Absent 5. The President declared the resolutions adopted.

Mr. Doherty moved that the Business and Finance Committees be authorized to expend the proceeds from the sale of bonds, in purchase of land, and improvements on the fair grounds, as these committees acting jointly may determine. Carried.

It was resolved, that the price of admission to the grand stand be left with the Business Committee.

Mr. Aitken offered the following resolution:

Resolved, That it is the sense of this committee, that the Business Committee and the Finance Committee, acting together, should arrange for the employment of a competent and experienced man to act as manager of the state fair, who shall devote his whole time to the interests of this association, and who shall have no other business or occupation while so employed. Carried.

On motion it was resolved, that the holders of the concessions be required to pay the same price for the same class of privileges.

Mr. Stevenson presented the following resolution:

Whereas, during the past year, there has been considerable discussion among the members of the State Grange and Farmers' Clubs throughout the state, on account of the bar and liquor privileges allowed on the State Fair grounds, and

Whereas, at the meeting of the Farmers' Clubs held in Lansing last month, our General Superintendent, Mr. A. J. Doherty, addressed the representatives of the Farmers' Clubs and assured them that he would use his influence to see that no bar or liquor privileges would be connected in any manner with the State Fair during the year 1910 and, in consideration of there being no bar or liquor privileges on the grounds for 1910, the Farmers' Clubs passed a resolution agreeing to support and uphold the Fair, and

Whereas, it is understood that the State Grange took a similar position,

Therefore, be it resolved that it is the sense of the Executive Committee of the Michigan State Agricultural Society that there be no bar or liquor privileges of any sort granted for the Fair of 1910.

The adoption of this resolution is moved by A. E. Stevenson and seconded by T. F. Marston.

Mr. Doherty moved that the matter of a bar at the Fair be left with the President. After discussion the motion was withdrawn.

Mr. Stevenson moved as a substitute for his resolution, that the matter of sale of liquor on the grounds be left with the President. The substitute and motion were both adopted.

On motion of Mr. Doherty, the committee proceeded to the election of general superintendent.

It was moved and supported that the Secretary be instructed to cast the ballot of the committee for Mr. D. D. Aitken. Ballot so cast and Mr. Aitken was declared elected.

It was moved that the Secretary be instructed to cast the ballot of the committee for Thos. Newton for member of the Business Committee. Motion carried; ballot so cast, and Mr. Newton declared elected.

A recess was taken until three o'clock p. m.

Committee met at three o'clock.

The committee to confer with Harley & Atcheson, regarding their bill for services, reported as follows:

Your committee reports that, without prejudice and for the purpose of settlement we recommend the payment of two hundred and fifty dollars ($250.00) in full settlement of the claim of Harley & Atcheson and on the further condition that they deliver to the Society all plans and specifications covered by the bill presented.

The report and recommendations of the committee were adopted.

The President announced the appointment of committees and executive superintendents as follows:

Finance committee—Mr. Doherty, Mr. Fifield, Mr. Peek.

By-Laws and Rules—Mr. O'Keefe, Mr. Snell, Mr. Whelan.

Premium List—The Business Committee, The Finance Committee, and Mr. Stevenson.

Reception committee—Mr. Rich, Mr. Snell, Mr. Whelan.

Program committee—The Business and Finance Committees.

DEPARTMENT SUPERINTENDENTS.

Cattle—C. A. Tyler.
Horses—Sherman T. Handy.
Racing Committee—Mr. Newton, Mr. Fifield, Mr. Peek.
Sheep—F. Jay Lessiter.
Swine—Geo. Kelly.
Poultry—S. D. Lapham.
Agricultural Products—W. J. Terney.
Dairy and Domestic—T. F. Marston.
Apiary—F. B. Ransford.
Vehicles—A. E. Stevenson.
Farm Implements and Machinery—V. V. Green.
Art—A. H. Griffith.
Needlework—Mrs. Belle F. Clark.
Horticulture—L. R. Taft.
Educational—Thos. Sattler.
Main building—Mr. ————
Concessions—The Business and Finance Committees.
Transportation—Geo. W. Dickinson.
Chief Marshall—H. C. Bowen.

On motion the appointments made were confirmed and those not made considered as confirmed when made.

The construction of a floor in the main building to replace the present floor was left with the Business Committee with power to act.

On motion permission was given the National Foundrymen's Association to use the buildings and grounds for a meeting and exhibition June next.

On motion of Mr. Stevenson, the amount to be appropriated for the Speed Department was left with the Business Committee with authority.

On motion, the President appointed a committee to recommend salaries of officers for the ensuing year: Mr. Doherty, Mr. Stevenson, Mr. Whelan. Also to recommend amounts of bonds to be required.

The committee reported as follows: Your committee on salaries of officers make the following report:

1st. That inasmuch as this year we have changed our management so that the business is to be transacted by Business and Finance Committees jointly, thus increasing our board of management to seven members; we recommend that no salary be paid the members of these committees, but that they receive three dollars per day when employed on the business of the Society, and necessary expenses.

2nd. That the salary of the Secretary be $1,200.00 and that of the Treasurer be $400.00.

3rd. That the bonds of officers be; for Secretary $2,000.00, for treasurer $5,000.00 and such further sums as the Business Committee may require, and for the Manager, not less than ten thousand dollars ($10,000.00) as may be determined by the Business and Finance Committees; and that all fees be paid

by the Society. All bonds to be approved by the President and kept on file in his office.

Signed, A. E. STEVENSON,
A. J. DOHERTY,
N. J. WHELAN,
Committee.

The report of the committee was accepted and adopted.

A bill for $105.00 for loss of mule was presented by Louis Schnell. On motion, the bill was referred to the Business and Finance Committees.

The matter of construction of sections of improved roads on the Fair Grounds presented by Mr. Green, was left with the Business and Finance Committees.

On motion adjourned.

Meeting of the Business and Finance Committees Wednesday, January 12th, 1910.

All members present. The matter of securing membership in the Grand Circuit, was considered and it was decided to make application for such membership. A letter was prepared and sent through Mr. Collier.

The appointment of a manager was taken up and Mr. Chas. Floyd of Grand Rapids was offered the position. On motion adjourned.

Meeting of the Business and Finance Committees Monday, February 14th, 1910.

Committees met. All members present except Mr. Doherty.

Proceeded to canvas the vote taken by letter on changing the date of the fair of 1910, with the following result: In favor of the change, 17. Against the change, 5. Not voting, 6.

On motion of Mr. Aitken, the change was declared carried and the dates fixed for Sept. 19-23, 1910.

Mr. C. A. Floyd having declined the position of manager, after considering several applications on file, on motion of Mr. Fifield, Mr. Aitken was authorized to engage Mr. J. E. Hannon of Flint, Mich., at a salary of $2,400.00 per annum.

It was agreed to appropriate the sum of $28,000.00 for race purses for the next fair to be used under the direction of the Racing Committee.

The following sub-committees were appointed: Racing Committee, Messrs. Newton, Fifield, Peek. Concessions, Attractions and Shows, Messrs. Postal, Newton, Doherty. On motion adjourned.

Meeting of the Business and Finance Committees held March 7th, 1910. Present, Messrs. Aitken, Fifield, Peek, Newton, Butterfield and Postal.

On motion, the Superintendent of Implements and Machinery, Mr. Green, was authorized to expend not to exceed five thousand ($5,000.00) dollars in the purchase of material for the purpose of constructing sections of improved roads on the Fair Grounds.

Mr. Marston was authorized to arrange for a test of different breeds of dairy cows, at the Fair of 1910.

Mr. Marston was added to the Premium List Committee.

A communication was received from the Michigan Portland Cement Manufacturer's Association relative to a building for exhibition.

The manager was directed to correspond with the Association on the subject.

A communication was received from C. E. Hoyt, secretary of the National Foundrymen's Association, relative to a cement floor in the Main Building. The matter was put over to the next meeting.

Messrs. Newton, Postal and Hannon were authorized to attend a meeting in Chicago, of representatives of other State Fairs, on March 22nd.

The resignation of I. H. Butterfield, Secretary, to take effect March 31st, 1910 was received and accepted.

On motion, Mr. J. E. Hannon was appointed acting Secretary to fill the unexpired term.

An informal discussion regarding new buildings was held. No action. It was resolved that the dates of the next Fair be extended to include Saturday, September 24th, making the dates Sept. 19-24.

Mr. A. H. Moone was appointed Racing Secretary at a salary of $1,000.00.

The President added L. R. Taft to the Premium List Committee.

On motion adjourned.

I. H. BUTTERFIELD, Secretary.

MICHIGAN A PIONEER IN AGRICULTURAL EDUCATION.

The beginning of public work in agricultural education in Michigan, was the organization of the Michigan State Agricultural Society.

In 1849, the Legislature, by an act approved April 2nd, created the Michigan State Agricultural Society. Section 3 of this act provided for an annual report "embracing such accurate details of the modes of cultivation, of keeping stock, and of the other important incidents, as will acquaint farmers and others with the precise manner in which the valuable results recorded can again be obtained:" thus indicating that the object of the Society was education in the line of practical agriculture.

Soon after this Society was organized, its officers began the agitation for an agricultural school, to be supported by the state.

Hon. E. H. Lothrop in an address at the first Michigan State Fair, September 1849, said, "Is there no practical remedy for these difficulties that now beset and retard our advancement in agricultural improvement? we answer that in our opinion a thorough and well educated yeomanry in the science and practice of agriculture would have the much desired effect.

"Let us educate those of our sons intended for the future profession of agriculture thoroughly in everything that pertains to that business. Make our common schools what they should be and let the branches there taught have a direct reference and bearing upon the future business of our children. If our common schools shall be found insufficient or too expensive to accomplish the purposes here indicated, there is sufficient wealth in the country to warrant the establishment of country or state schools where the elementary principles taught in our common schools might be tested by experiment and application.

"Our State University might have been made a powerful auxiliary in the cause of agricultural improvement, if its foundation had been laid with direct reference to the character and pursuits of the people of our state."

Hon. Wm. M. Fenton, then Lieut. Governor of the State, in an address, delivered at the Calhoun County Fair, September 2, 1849, said—"There can be no good reason given why the art of agriculture should not be taught in schools, as well as any other. Let it be taught as an art or science, with a professorship in our University, and you will at once have raised to a level with other professions, that which is acknowledged by the unprejudiced, to be the most ancient and honorable."

At the annual meeting of the Executive Committee of the Michigan State Agricultural Society, held at Jackson, December 19, 1849, Mr. Bela Hubbard, offered the following resolution which was adopted;

Resolved, That our Legislature be requested to take such legislation as shall appear necessary or expedient for the establishment of a State Central Agricultural Office, with which shall be connected a museum of agricultural products and implements, and an agricultural library, and as soon as practicable, an Agricultural College and a Model Farm.

In support of this resolution, Mr. Hubbard said—"We would have Michigan as distinguished for her encouragement of agriculture, as for her system of education. In the kindred cause of the proper culture of her soil, she has already, by the establishment of a State Society and holding a State Fair, taken the lead of all the states west of the Alleghanies. It remains for her to place this great interest upon as permanent a basis as that of her common schools, and thus give a great, practical illustration of the motto of the late distinguished Judge Buel—'To cultivate the soil and the mind.'"

Gen. Lewis Cass, in an address delivered at the Kalamazoo County Fair, October 11, 1850, said—"There is one great error, to which public attention is now directed and which ought long since to have found a corrective, and that is the too prevailing impression that education, at least to any considerable extent, is unnecessary for those who intend to devote themselves to the pursuit of agriculture."

Hon. Joseph R. Williams, afterward the first President of the Michigan Agri-

cultural College, in an address at the State Fair at Ann Arbor, September 26, 1850, said—"To afford the rising generation of farmers abundant opportunity to put theory to practical tests, and to qualify themselves for their future occupation, the establishment of agricultural schools has been a favorite plan with many." "So far from being less, I deem peculiar schools devoted to their interest more necessary to the farmer than any other citizen."

Dr. M. A. Patterson, in an address at the Lenawee County Fair, October 4, 1850, said—"You have a State University richly endowed by the sale of public lands. In this University is taught whatever is considered necessary to qualify a young man for the higher walks of life. There you have twelve different professorships in the hands of several professors, presenting an imposing array of literary ability. Now let a farmer enter this temple of science and inquire 'What has all this to do with my business,' and an echo from the walls will respond to his inquiry—'Nothing.'

"Gentlemen, you and your fellow agriculturalists throughout the state, have the power and influence to remedy this defect in our University. You have only to say that a professorship of agriculture shall be established, not as contingent or collateral to some other department, but solely and exclusively devoted to instruction in scientific agriculture, and it will be done. Then, and not till then, will the interests, the honor and the dignity of the cultivators of the soil be faithfully and fairly represented in Michigan."

It will be seen that the question of agricultural schools and the establishment of an Agricultural College or a department of agricultural education in the University, had at this date received much attention from the leading men of the state, a state in which at that time agriculture was the greatest business.

The Legislature of 1850 adopted the following:

JOINT RESOLUTION NO. 20, LEGISLATURE OF MICHIGAN.

Public Acts Session 1850.

Joint resolution relative to a donation of land by the general government for the establishing of agricultural schools and for other purposes. Resolved, that our Senators and Representatives in the Congress be requested to use all honorable means to procure of the United States, a donation of three hundred and fifty thousand acres of land to this state for the purpose of establishing and maintaining agricultural schools therein, at such places and under such regulations as the Legislature thereof may prescribe, and also to procure a donation of ten thousand acres of land to aid the Michigan State Agricultural Society in establishing and maintaining a control office and library for the use of the Society, and also to use their best endeavors to procure the passage of a law to establish a Bureau of Agriculture in the Department of the interior or some other appropriate department at Washington, whose province shall be to superintend and to promote the great interest of the agricultural improvements in the nation.

Resolved, That the Governor of this State be requested to forward copies of this resolution to the President of the Senate and the Speaker of the House of Representatives in Congress.

Approved April second, 1850.

CONSTITUTIONAL PROVISION.

Section 11, of the Constitution of 1850, provided: "The Legislature shall encourage the promotion of intellectual, scientific and agricultural improvement; and shall, as soon as practicable, provide for the establishment of an agricultural school. The Legislature may appropriate the twenty-two sections of salt spring lands, now unappropriated, or the money arising from the sale of the same, where such lands have already been sold, and any land which may hereafter be granted or appropriated for such purpose, for the support and maintenance of such school, and may make the same a branch of the University for instruction in agriculture and the natural sciences connected therewith, and place the same under the supervision of the Regents of the University."

Section 2, of an act approved March 25, 1850, amending laws relative to the State Normal School, provided—"That a State Normal School be established, the exclusive purposes of which shall be the instruction of persons both male and

female in the art of teaching and in the various branches that pertain to a good common school education. Also to give instruction in the mechanic arts, and in the arts of husbandry and agricultural chemistry; in the fundamental laws of the United States and in what regards the rights and duties of citizens."

Section 7. "Said Board shall have power and it shall be their duty from time to time, as the means at their disposal may warrant; to provide suitable grounds and buildings, implements of husbandry and mechanical tools, for the purpose of more effectually and experimentally carrying out the provisions of the second section of this act to give instruction in the mechanic arts and in the arts of husbandry and agricultural chemistry."

At the annual meeting of the Executive Committee of the Michigan State Agricultural Society, held at Detroit, December 14, 1852, the following communication was presented:

STATE OF MICHIGAN,
Office of Supt. of Public Instruction,
September 21, 1852.

J. C. Holmes, Esq.,
Sec. Michigan State Agr. Society,

Dear Sir—Herewith I send you a circular notice, relating to the dedication of the State Normal School at Ypsilanti on the 5th day of October next.

My object in calling you attention to the subject at this time is the provision made in the law establishing this institution for instruction in the mechanic arts, the arts of husbandry and in agricultural chemistry. These are objects identical with the interests of the Society of which you are Secretary. Section 7 of this act provided that "the Board of Education shall have power and it shall be their duty from time to time to provide suitable grounds and buildings, implements of husbandry and mechanical tools for the purpose of more effectually carrying out the second provision of this act," which provides for instruction in these subjects. * * * it is respectfully suggested for the consideration of the State Agricultural Society, whether through its efficient and active co-operation with the Board of Education in carrying into effect the provision of law which requires instruction in the mechanic arts, the arts of husbandry and agricultural chemistry, something more useful and effective may not be accomplished than has heretofore been done practically in our state. * * *

The great interests therefore of education and agriculture can be there most practically identified and cherished. These views are thrown out as suggestions which it is hoped may lead to some more important action in the future, should it be deemed a matter of importance to the Agricultural interest of the state, in connection with one of its most practical educational institutions. I have the honor to be, sir,

Very respectfully, your obedient servant,
FRANCIS W. SHEARMAN, Supt. Pub. Inst.

Dr. Tappan, President of the University, also became interested in an agricultural school as a part of the University, and wrote the following letter to the Secretary.

Michigan University, Dec. 1852.

J. C. Holmes, Esq.,
Sec. Michigan State Agricultural Society,

Dear Sir—Knowing full well that everything connected with the progress of agricultural science must prove interesting both to yourself individually and to the Society of which you are a member, I take this opportunity of laying before you some measures which have been adopted by the Regents and faculty of the University in relation to the establishment of an agricultural school.

You are aware that the legislature is empowered by the new constitution to appropriate twenty-two sections of salt spring lands for the maintenance of an agricultural school, and that they "may make the same a branch of the University for instruction in agriculture and the natural sciences connected therewith, and place the same under the supervision of the Regents of the University." In anticipation of this legislative grant, we have accordingly organized an agricultural school as a part of the scientific course recently adopted by the faculty and Regents.

There follows a list of subjects embraced in this agricultural course, lectures on chemistry, geology and mineralogy, animal and vegetable anatomy and physiology organic chemistry.

(Signed) HENRY P. TAPPAN.

At this meeting, the following resolution was adopted, "Resolved, That Messrs. Dort, Shoemaker and Moore, be a committee to urge upon the legislature the propriety of carrying into immediate effect the 11th section of the 13th article of the Constitution of the State, relative to a State Agricultural School, with the advice that it be adopted as a branch of the University and placed under the control of the Regents and that such instruction and lectures of the professors shall be secured; that such measures be taken as will lead to the final establishment of a model and experimental farm; that the permanent location of said school lands, which should henceforth be reserved from sale, should be on a tract or tracts of not less than 640 acres of university lands; and that in view of this Society, the contemplated school and farm should not be established in immediate proximity to any existing educational institution; and that the income of the salt spring or other lands, named in the Constitution be inviolably set apart for the support of said school."

In an address delivered at the State Fair, September 1853, President Tappan said, "I say, farmers of Michigan, that our great desire is to make the University useful to you, and we are determined to do it. We will educate all your sons who wish to be educated for the different professions, and beyond this we have established and will carry on an agricultural department for those who intended to devote themselves particularly to agriculture." On the 14th of March, 1853, a circular was issued by the Regents of the University, announcing that there would be a free course of lectures in the University of Michigan upon agricultural science, commencing on the 27th day of April and closing the 28th day of June.

The Rev. Chas. Fox was announced as lecturer upon theoretical and practical agriculture, other lectures to be given by Prof. S. H. Douglas and Prof. A. Sager. This course of lectures was given in accordance with the above announcement.

In the autumn, Mr. Fox moved to Ann Arbor and lectured during the winter. He was afterward appointed Professor of Theoretical and Practical Agriculture and was expecting to continue in that department, but early in the summer of 1854, he was removed by death.

The legislature of 1855 having established an agricultural college, no further steps were taken to continue agricultural education in the University.

At a meeting of the Executive Committee of the State Agricultural Society in December 1854, it was resolved "that an Agricultural College should be separate from any other institution." Mr. Justus Gage from the committee to report a memorial to be presented to the legislature on the subject of an Agricultural School, reported a memorial, praying that body to appropriate a sum of money sufficient to purchase a body of land for an experimental farm, and for the erection of suitable buildings thereon for an agricultural school, placing it on a basis of its own, separate from any other institution of learning, and for the endowment of the same, in such manner as shall place it upon an equality with the best colleges of the state.

The memorial was accepted and adopted and Mr. S. M. Bartlett was appointed to draft a bill to be presented to the next legislature for the establishment of an agricultural school, in accordance with the views of this committee, as by them already expressed.

In January 1854, on invitation of the President of the University and of the Principal of the State Normal School, the executive committee visited these institutions for the purpose, as stated, "to ascertain the measures adopted by these institutions in teaching agricultural science."

The committee in reporting on this visit at the institutions named, stated that they found that instructive and valuable lectures were being delivered but "we do not think the information to be derived from these sources is sufficient to constitute the education of a professional and practical farmer, and recommended petitioning the legislature for an appropriation of monies arising from the sale of swamp lands, sufficient for the purchase of a farm, where practical and scientific agricultural education will be taught on a scale corresponding with our increasing wants and growing state."

The Agricultural College Established. The Legislature which convened the first Wednesday in January, 1855, passed an act which was approved by the Governor * * * for the establishment of an agricultural school. Section 1 reads: "The People of the State of Michigan enact: that the President and Executive Committee of the Michigan State Agricultural Society be and are hereby authorized to select, subject to the approval of the State Board of Education, a location and site for a State Agricultural School within ten miles of Lansing: and subject to such approval, contract for and purchase for the State of Michigan, such lands, not less than 500 acres, nor more than 1,000 acres, in one body, for the purchase of an experimental farm and site for such agricultural school; provided that the amount to be paid for such farm and site, shall not exceed fifteen dollars per acre and that the conveyance or conveyances be made to the State of Michigan, Sections 2 and 3 relate to the appropriation and payment of this land.

Section 4; "Upon the purchase of such location and site, there shall be established on such site under the direction and supervision of the State Board of Education, an agricultural school by the name and style of the Agricultural College of the State of Michigan, and the chief purpose and design of which shall be to improve and teach the science and practice of agriculture."

Section 5; "The course of instruction in said college shall include the following branches of education, viz.: an English and scientific course, natural philosophy, chemistry, botany, animal and vegetable anatomy and physiology, geology, mineralogy, meteorology, entomology, veterinary art, mensuration, leveling and political economy, with bookkeeping and the mechanic arts which are directly connected with agriculture, and such others as the Board of Education may from time to time see fit to prescribe, leaving reference to the objects specified in the previous section; and the said board may establish such professorships and employ such professors and teachers to be called the Board of Instruction of said college, for the instruction aforesaid, as they may judge best for such object." Tuition was made free to pupils from the state.

Manual Labor.

Section 7; provided that: "The Board of Education, upon consultation with the Board of Instruction, shall from time to time, fix and establish such rules as to the number of hours which shall be devoted to manual labor and to study, which may be different in different terms or seasons; but during the first term in each year (summer term) the time devoted to labor shall not be less than three nor more than four hours per day; and no student or pupil of said college shall be exempt from such labor, except in case of sickness or other infirmity."

Selecting the Site.

In accordance with the provisions of this act, the executive committee met at Lansing on Tuesday, June 12th, 1855, for the purpose of receiving proposals for lands upon which to locate said school and farm, and to make a selection for such site.

A number of proposals were received. The one proposing the present farm site on which the college is located, containing 676 57-100 acres, was accepted, subject to the approval of the State Board of Education (which was given). This report was signed by

A. Y. MOORE, President.
S. M. BARTLETT,
PAYNE K. LEECH,
JAMES BAYLEY,
JUSTUS GAGE,
JOHN STARKWEATHER,
Executive Committee.
J. C. HOLMES, Secretary.

Thus was established the first State Agricultural College in the United States. A corps of professors, to be supported by the State or Government, and the first of any kind to be fully organized and equipped for a course in agriculture and allied subjects, having been chosen and the institution prepared for the reception of students, it was dedicated by the Board of Education to the purpose

for which it was designed with appropriate services, on the 13th day of May, 1857, in the presence of the Governor, several officers of the State Government, and a large concourse of citizens from various parts of the state.

Hon. Joseph R. Williams of Constantine, a graduate of Harvard, was first president, and sixty-one students enrolled for the first term.

As indicating the position of Michigan as a state in the establishment of Agricultural Colleges, it may be mentioned that in 1857 in the House of Representatives in the U. S. Congress, a bill donating public lands to the several states and territories, which may provide colleges for the benefit of agricultural and the mechanical arts, having been referred to the committee on public lands, the majority reporting against the bill, Hon. David S. Walbridge, member from the third district of this state made a minority report of great length, recommending the passage of the bill.

Joint resolution relative to grant of lands. In January 1858, the Legislature passed the following Joint Resolution "Relative to a grant for the endowment of the Michigan Agricultural College."

"Whereas; a Memorial has been presented to Congress by the Board of Education and the President and Faculty of the Michigan Agricultural College, praying for a grant of land as an endowment of said Michigan Agricultural College; and whereas, we believe that the practical working of the Michigan Agricultural College fully vindicates the feasibility and correctness of the principles on which it is founded,

"Therefore; resolved, That our Senators and Representatives in Congress be instructed to use all honorable means to secure the passage of a law in accordance with the Memorial.

Resolved, That the Governor be requested to forward the foregoing preamble and resolutions to each of our Senators and Representatives in Congress."

Approved, January 29, 1858.

Short Courses.

In the report of the State Board of Education for 1860, page 59, we find the following suggestion for short courses.

"In teaching agriculture, the Board would suggest whether there might not be established a lecture term to be held in the winter, in which courses of lectures should be given by the several professors on the topics of their departments.

Large numbers of farmers would find leisure in winter to attend a course of lectures on farming, and while the college was thus extending its usefulness, it would be attracting many students who might conclude to pursue its full course of studies."

I. H. BUTTERFIELD.

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